Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. IX. NEW YORK, JULY, 1904. No. 5.

"Compressed Air"

Published Monthly.

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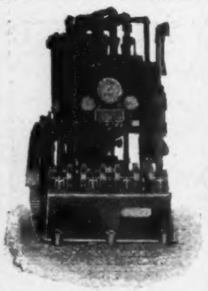

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
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Moisture in Compressed Air.

One of the greatest arguments which has been urged against the central compressed air power transmission plant has been the danger of freezing at the machines as the air was used. It is a common error to speak of the air freezing. As a matter of fact, air does not freeze, although it may become a liquid and finally a solid when subjected to extreme cold and pressures. It is the moisture carried in the air which is the cause of all the trouble. When the air pressure is reduced its temperature is lowered. If there is moisture in any quantity in the air it will be condensed and, if the temperature is low enough, it will be frozen. If this happens in a machine which is driven by the pressure of the air it results in serious inconvenience.

Before these facts were realized, users of compressed air suffered much inconvenience from freezing in the machinery. It has now been successfully demonstrated that if the moisture is removed the air can be piped long or short distances and used for the operation of a variety of machinery without the slightest danger from freezing. The problem of removing the moisture effectively but economically has received much attention and records of some of the recent achievements in this field show that it has been successfully solved.

Readers of COMPRESSED AIR will remember the central compressed air power plant which was operated with success during the building of the Jerome Park Reservoir. Despite the cold weather which prevailed part of the time the plant was in operation there was not a single instance where the air pipes or machines were closed by frost. A still larger installation, in which this fact has been brought out with greater certainty, is that recently made by the Cleveland Stone Company. Mention of this plant has already been made in COMPRESSED AIR. A detailed description is given for the first time in this issue. The remarkable results obtained will undoubtedly lead to the adoption of similar plants, not only for quarry work but along other lines where compressed air can be used just as advantageously.

Caisson Disease.

Special attention has recently been called to the dangers of working under air pressure. A number of cases of "the bends" have been reported in the vicinity of New York where men are employed for tunneling by the shield method of caisson work. This form of illness is by no means new, but the unusual number of cases within the last year has attracted attention to it.

It has generally been credited that the disease was in a large part due to a too sudden reduction in the pressure. This

view has been substantiated by an investigation of the subject recently made by Leonard Hill, M. B., F. R. S., lecturer on physiology at the London Hospital, and J. J. R. Macleod, M. B., professor of physiology at the Western Reserve University, Ohio. The results of their researches were published in the *Journal of Hygiene*, and an abstract of this paper subsequently appeared in the *Engineering News*. It is interesting to note the comments made. Editorially the *Engineering News* says:

"We risk little in saying that the elaborate article in this issue on the effects of compressed air on the human system and the cause of the disease known as "the bends" is the most valuable contribution ever made to the literature of this subject. The authors of this paper, as a result of most exhaustive investigations, have proved that the cause of the bends is nothing but the escape of air or gas bubbles from the blood in the circulatory system when the air pressure is reduced. The veins of a man who is attacked with the bends in passing out of an air lock are in a condition comparable to that of a soda water bottle when the cork is removed. Bubbles of air or gas which have been absorbed by the blood and tend to derange the circulatory system in a variety of ways. One way which appeals particularly to engineers, because of its mechanical nature, is the effect on the heart. As everybody knows, the heart is simply a pump which nature has provided to force the blood through the circulatory channels. If air bubbles are formed all through the veins and arteries of a man coming out of compressed air, these bubbles will tend to coalesce and increase in size as they flow along. Some of them may collect at high points, as they do in an engineer's pipe line, and remain there until the whole mass is forced at a gulp toward the heart. The pumps which the engineer builds for moving water work very badly for pumping air, and Nature's pump likewise works badly when air instead of blood enters it. There appears to be no doubt that this is one explanation of the sudden deaths which at times occur on leaving an air lock.

"And now that the cause of the disease is definitely known, the method of its prevention is equally plain. It is in fact what has been understood by experts for years to be the proper method of preventing the bends, viz.: making the working shift short and come out very slowly through the air lock.

"If the shift is short the blood does not have time to become charged with with the full quantity of gas which it would absorb under the high pressure. If the passage through the air lock is slow the gas driven off by the blood will be gradually eliminated through the lungs without serious interference with the action of the heart or the capillaries.

"We will not take space further to trace the action of the compressed air on the system, for the important point, deserving of chief attention, is that the prevention of the bends, now that the cause is known, is a duty incumbent on every engineer and contractor who works men in compressed air. Common humanity, as well as the common law, dictate that employees shall not be exposed to any danger which due diligence, the use of reasonable foresight and the adoption of well-known methods can prevent. Every air lock should have an adjustable locked escape valve, which should prevent the men from passing through the lock at any time faster than safety will permit. This should be adjusted from time to time to suit the depth of excavation and the pressure of the air. As soon as any symptoms of the bends are detected it is to be taken as an indication that the shifts are too long, or the time of passage through the air locks too short, and

the proper amendments should be immediately made.

"If this is not done and if a number of men die or are crippled by the bends there is good reason to suppose that the contractor could be mulcted in heavy damages, just as if the men had suffered from some accident due to defective material which he had furnished. It is doubtful if this responsibility could be evaded, even by an employment contract absolving the employer from liability for damages due to diseases caused by the compressed air. The law does not sanction contracts by which a man forfeits his right to the reasonable protection of life and limb. It has been held that contracts which tended to make an employer careless of the safety of those whom he employs were against public policy, and therefore void.

"We do not assume, of course, to express any legal opinion in the case, but it seems at least clear that it will pay a contractor, from mercenary motives as well as from motives of humanity, to safeguard to the fullest possible extent his employees working in compressed air, and he can now do this with intelligence and certainty."

The Compressed Air Power Transmission Plant of the Cleveland Stone Company.

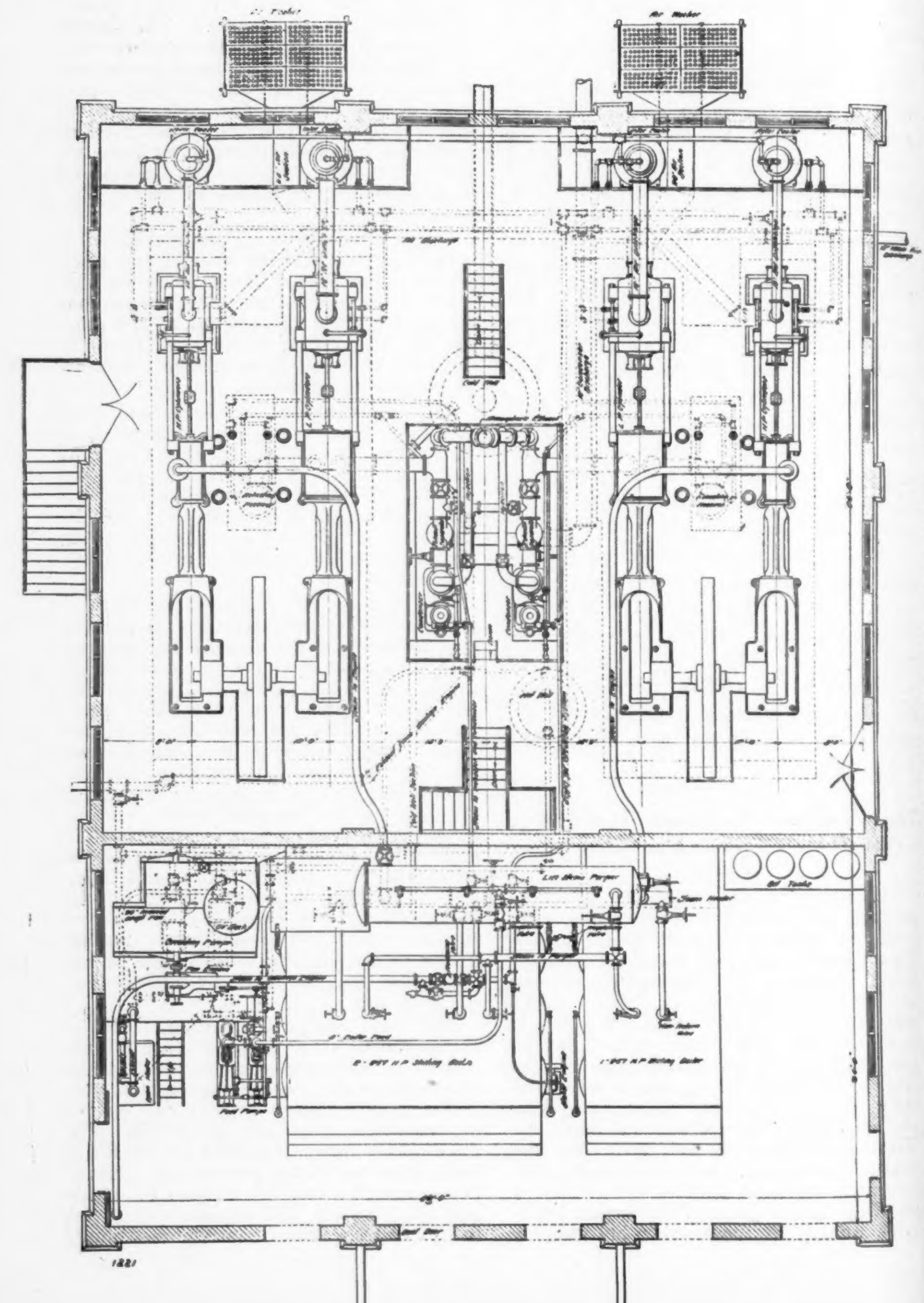
The most recent application of compressed air power to transmission purposes on a large scale is found in the plant recently installed for the Cleveland Stone Company on its quarry property near North Amherst, O., about thirty miles from Cleveland. Work was begun on the plant in July of last year. The system, covering the ground as originally intended, has been in operation since the early part of this year. But extensions are now under way which will mean an increase of about 50 per cent. over the original scope of the enterprise. The present installation handles the output of the Gray Canon Quarry, the largest sandstone quarry in the world; but the air lines are being extended to supply power to two neighboring quarries. The system is a typical example of the modern idea of centralized and economical power replacing a number of scattered units operating at low economy and under unfavorable conditions. The results achieved in four months of operation have been almost startling and seem to merit a detailed description of the means by which they were secured.

Outlined briefly, the plant consists of a central air compressing plant, from which power is distributed by means of air pipe lines to the various machines throughout the quarry. The system retains the same quarry machinery which was formerly operated by steam generated in a number of isolated boiler plants.

The power-house is a brick and steel structure, located on a spur of the L. S. & M. S. Ry., at a point near the centre of the group of properties owned by the company at this place. A fire wall divides the interior into the boiler-room, 34 feet by 69 feet 6 inches, and an engine-room, 63 feet 6 inches by 69 feet 6 inches, inside dimensions.

The floor of the engine-room, of steel and concrete construction, is elevated 9 feet above the boiler-room level, leaving a basement which contains the condensation pump, condenser piping and some other auxiliaries. The condensers and inter- and after-coolers, are also located on this level, extending into the engine-room above through areas in the floor. Access to the boiler-room is secured through a fire-door on the basement level. The interior of the engine-room is painted white and large windows on three sides secure exceptionally good ventilation and lighting. The chief engineer's office on the engine-room floor commands a view of the entire machinery installation. The location of the building is such that future extensions may be made by additions on the west side.

The main engine foundations, built of the sandstone from the quarry, are fine examples of masonry foundations. Heavy connecting walls bind the two sections together, and a heavy cement cap on the top makes a practically solid unit. The main engine frame is bedded to a depth of about 2 inches in the cement cap. Heavy plates bedded in the cap support the steam and air cylinders, and any movement due to expansion and contraction simply


Air Washer
Air Washer
Ash Skip
Lift Steam Purifier
Oil Tanks
Steam Header
Boiler Feed
Feed Pumps
1221

causes the cylinder feet to slide on these plates.

Coal storage capacity for 650 tons is provided in bins on the north side of the power-house, served by an elevated siding from which hopper-bottomed cars discharge direct. The bins extend the full length of the boiler-room and openings in the wall admit the coal direct to the floor in front of the boilers. Fuel is delivered by hand from the floor to the stoker hoppers, and ashes are removed in barrows to a dump outside. The size of the plant did not justify the installation of coal and ash handling machinery, as the boiler-room force would not be reduced thereby. As additions are made, a point will be reached when the expenditure will be justified and this refinement will then be added.

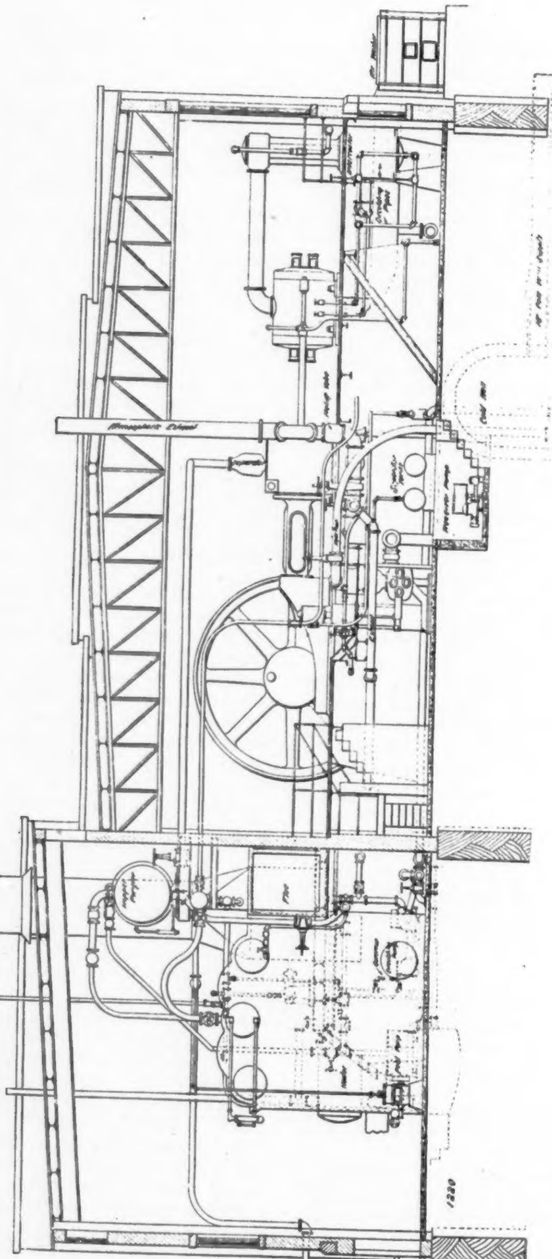
The boiler plant includes three water-tube boilers of 257 horse-power rated capacity, designed for 180 pounds pressure. The extension of the system to supply the two neighboring quarries, not originally provided for, will necessitate the use of the fourth unit of the same size, which is now being installed. The boilers are set in batteries of two. Mechanical stokers are used, driven from a common jack-shaft by a small vertical engine located between the two battery settings. Mechanical induced draught is furnished by a 90-inch fan driven by a small horizontal engine; this equipment doing the work of a 250-foot stack at an original cost of about one-fifth that of a natural draught installation. Automatic regulating valves control the supply of steam to the fan engine and maintain the boiler pressure within a few pounds on either side of the normal. The breeching is raised to provide a free passage in the rear of the boiler settings, where much of the auxiliary piping is placed, and leads directly, with no turns, to the fan elevated on a steel framework to the level of the engine-room floor. The 60-inch stack extends but a few feet above the roof. A high degree of combustion within the firebox is indicated by the fact that smoke is rarely seen rising from the stack, except when fires are being cleaned. High and low water alarms are furnished on each boiler, the water level being also automatically controlled.

Water for boiler feed and condensing purposes is secured from an abandoned quarry distant about a quarter of a mile from the plant. A direct acting plunger pump, located at the water's edge and driven by compressed air from the plant, delivers water to a storage tank near the power-house through 1,600 feet of 3-inch pipe. This tank or reservoir is of stone, cement-lined, and its capacity of 750,000 gallons assures a reserve sufficient to operate the plant for some days.

Analysis of the supply water showed the following proportion of solid matter:

	Grains per U. S. gallon.
Calcium carbonate	4.89
Magnesium carbonate	2.68
Calcium sulphate	2.96
Sodium chlorate	.65
Sodium carbonate	.66
Total solid matter	11.84

This analysis suggested the advisability of providing some system for removing the scale-forming substances from the boiler feed water. An open exhaust steam or primary heater is installed in the boiler-room, elevated well above the feed pumps. This receives the exhaust steam from feed and circulating pumps and from fan and stoker engines. A relief valve communicates between the heater and an atmospheric exhaust pipe. Valves are provided by means of which the heater may be cut out for inspection and cleaning, the auxiliaries discharging direct to atmosphere. A closed live steam, or secondary, heater is erected above the boilers, taking steam direct at boiler pressure. A hot well below the basement floor receives a portion of the main condenser discharge, the water level in the well being maintained constant by a float-controlled valve. The temperature of the condenser discharge varies, with that of the condensing water, from 80 degrees to 120 degrees Fahr. A circulating pump takes the feed water at this temperature from the hot well and elevates it to the primary heater, where its temperature is raised to 210 to 212 degrees Fahr. From the primary heater, the feed water flows by gravity to the boiler feed pump, which lifts it to the secondary heater where it is raised to a temperature corresponding to boiler pressure. From the secondary heater the purified water flows by gravity into the boilers. An automatic regulating valve in the feed pump steam supply pipe keeps the water level in the boilers practically constant. A regulating valve in the steam pipe to the circulating pumps controls the delivery of water to the primary heater. That the purifying system is effective is shown by



ELEVATION OF POWER HOUSE, CLEVELAND STONE CO.

the fact that repeated examinations of the boiler tubes have failed to show any scale whatever. The secondary heater has been cleaned once, after operating three months, and the upper elements were found heavily incrusted with scale-forming matter. The primary heater has thus far shown no appreciable deposit of solid matter. The company's locomotives are also supplied with boiler water from this central purifying system, delivered to a tank on the tracks. The value of this arrangement will be noted later in these lines.

The boiler feed pumps, installed in duplicate, are of single outside packed plunger pattern. The circulating pumps are of standard duplex plunger type. All pumps are direct acting, and are grouped with draught-blower and primary heater at the east end of the boiler room.

The functions of the two circulating pumps are distinct though the arrangement of pipes and valves is such that they may be interchanged. One normally handles the boiler feed water during the first stage, as described above. The other takes water from the cold well and circulates it through the air-cylinder jackets and inter- and after-coolers of the main compressor units discharging into the storage tank. Arrangements are also provided whereby the primary supply pump at the distant quarry may, on occasion, circulate its discharge through the air-cooling system, thus leaving free one circulating pump.

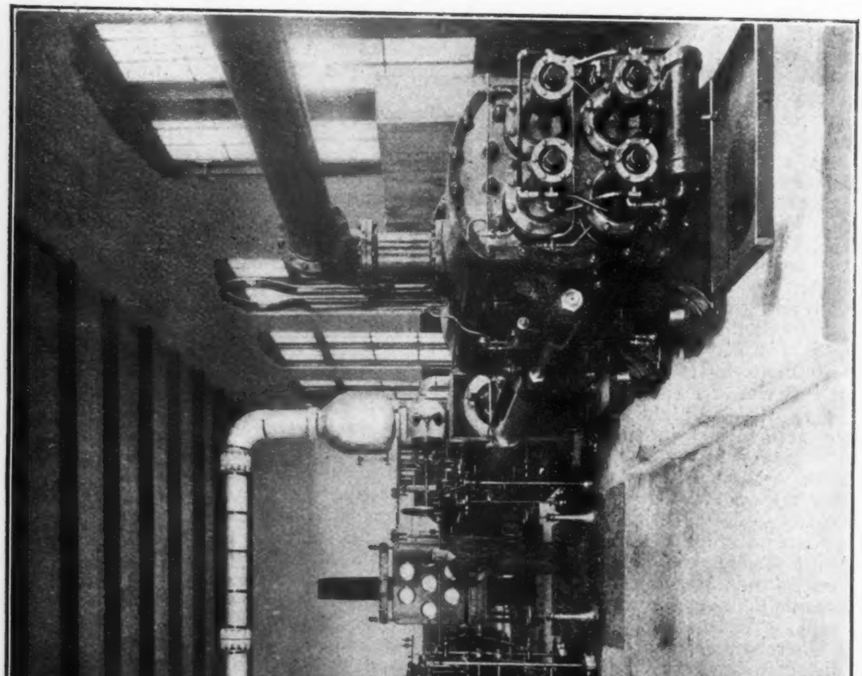
Jet condensers are used, each main unit having its individual condenser, driven by steeple compound engines. The steam to each condenser engine is drawn through the tubes of the reheating receiver of the main unit, passing through a steam separator before entering the cylinder. The exhaust is discharged into the receiver and does further duty in the low pressure cylinders of the main engines. The condensing water, at 60 to 80 degrees Fahr., is raised by the condenser vacuum from the cold well communicating directly with the storage tank, the condenser discharge flows by gravity to the cooling system outside. Oil eliminators remove all oil from the exhaust before it enters the condensers.

The cooling system is of novel construction. It was adopted in lieu of a cooling tower, to save the power required by the latter in driving the fan and elevating the condenser discharge. It consists of three sets of trays, of matched Louisiana cypress, each tray broken into riffles, and the three sets in tiers above the storage tank. A slight pitch is given each tray. The condenser discharge empties upon the higher side of the upper tray, is distributed over its length in a channel, and flows in thin sheets and cataracts to the lower edge. It falls to the tray below, where the operation is repeated, thence to the third tray, over which it flows into the tank below, making its fourth passage through the reservoir to the cold well. The arrangement gives about 30,000 square feet of cooling surface and the maximum air cooling effect is secured without any expenditure of power. The drop in temperature over the trays ranges from 20 to 40 degrees Fahr., depending upon the air temperature and humidity.

Steam piping throughout the power plant is of extra heavy pipe and fittings, with the exception of the main steam header, which is of gun-metal. Steam riser from boilers to purifier and header, and steam pipes from header to engines, are made up with wide sweep bends instead of elbows. The system of valves and duplicate piping is developed to give all possible assurance against a shut-down from the failure of any part of the piping. All pipe above 3 inches is made up with flanged fittings. Gate valves are used in all cases except for throttles. All live steam piping and boiler feed pipes are covered with 85 per cent. magnesia covering.

The main units of the compressor plant are steam-driven cross-compound condensing two-stage Corliss air compressors, built by the Ingersoll-Sergeant Drill Company, of New York. The steam cylinders are 20 and 44 inches in diameter; air cylinders 39¼ by 24¼ inches. The common stroke is 48 inches. At normal speed of 90 revolutions per minute each compressor has a low pressure piston displacement of 6,030 cubic feet of free air per minute and at 100 pounds air pressure indicates about 1,000 horse-power.

The usual flywheel governor is supplemented by a governor piston, normally balanced in a vertical cylinder between after-cooler pressure on one side and weights on the other. The governing operation is as follows: At normal air pressure, this piston maintains the steam cut-off at the proper point; when the air pressure falls below normal, the weights lower the piston and operate a rod which lengthens the cut-off, speeds up the compressor, and restores the pressure. When



ONE OF THE COMPRESSOR UNITS IN THE POWER HOUSE.

the pressure rises above normal, the piston rises, shortens the cut-off, and the speed is reduced until normal pressure is attained. It is noticed that either of these operations is followed by a gradual restoration of cut-off to almost normal value, though the speed of the compressor remains proportional to the demand for air. The device is simple, quick and positive. Air pressure is maintained constant within close limits. The flyballs become operaative only when the standard speed of 90 revolutions is exceeded—as when an air line should break or other sudden and abnormal demand be made upon the system. The usual safety device is provided for shutting down the compressor should the governor belt break.

The air valves, inlet and discharge, are of the Ingersoll positive air-thrown type, two inlet and two discharge valves being carried on each cylinder head. A piston on each valve stem is operative within a small cylinder in the valve bonnet carrying on one side standard air pressure, on the other a reduced pressure of about 1 pound. The lower pressure opens the valves at the proper time—the higher pressure holds them to their seats. The admission and release of high pressure air to the valve cylinders is controlled by a small independent slide valve device operated through a reducing motion from the main piston rod. There is no "chattering" of the valves, and indicator cards show none of the familiar irregularities in intake and discharge lines. The diagrams are practically ideal.

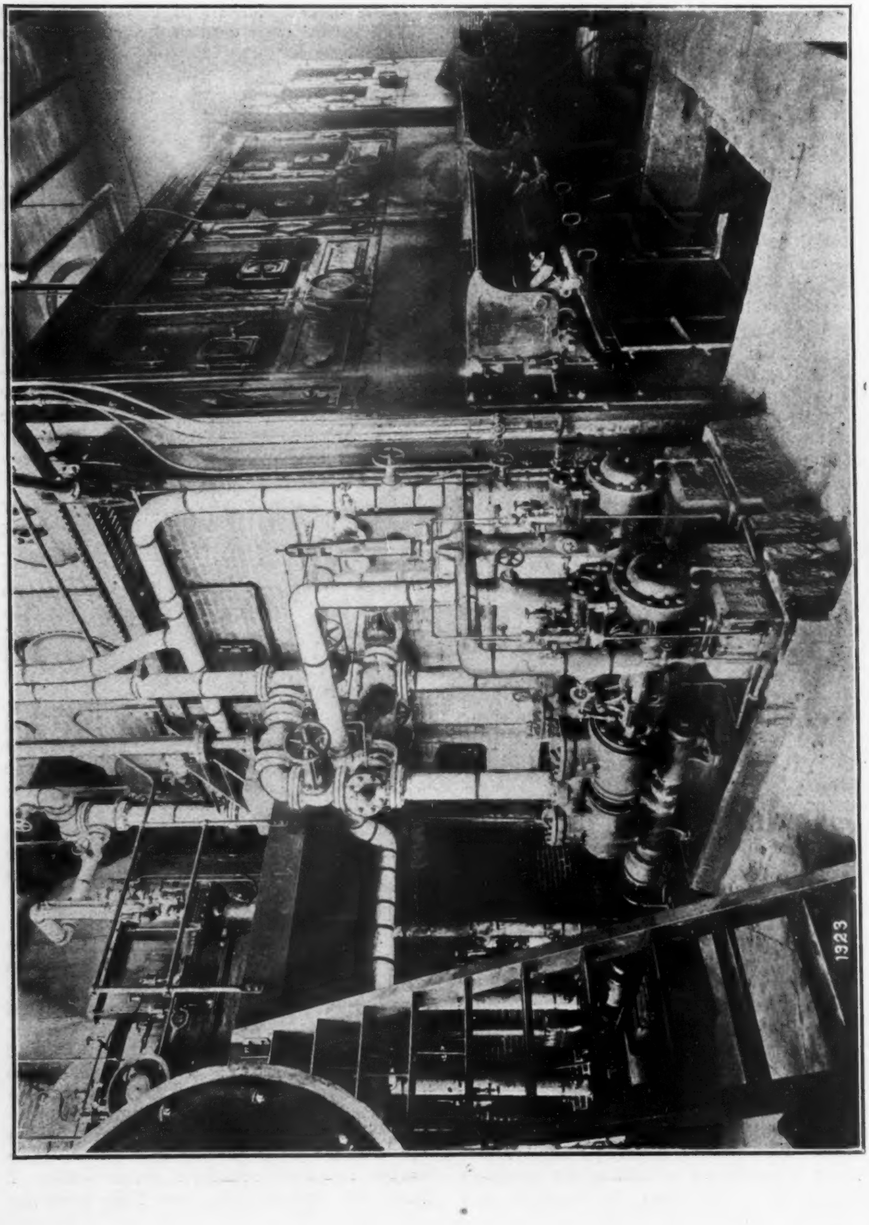
Air washers at the mouth of the low pressures intake conduits of each compressor serve the double purpose of keeping out from the cylinders the grit from the grindstone mills, and of cooling the intake air. Each washer contains 600 vertical tubes set in box or tank with their lower ends submerged about 2 inches in water. This water is constantly changing, the supply coming from a tank on the hillside above. The intake air is drawn into the upper ends of the tubes, down through the water and into the containing tank and intake conduit. Every particle of dust held in suspension is removed. Furthermore, the passage of the intake air, at, say, 85 degrees Fahr., through water at 55 degrees Fahr., means a material saving in fuel. For every 5 degrees Fahr., reduction in temperature of intake air gives an increase of 1 per cent. in capacity and efficiency of compression. The slight loss in friction of air through tubes and water is negligible.

The intake conduit of each compressor is 28 inches square in cross section. Low pressure discharge to inter-cooler is 16 inches in diameter; high pressure intake from inter-cooler, and high pressure discharge to after-coolers are of 10-inch pipe. Steam and exhaust pipes are 7 to 14 inches in diameter, respectively. Receiver separators are introduced in the steam pipe next to the throttle. The percentage ratio between air valve and cylinder areas is unusually great. The reheating steam receiver as mentioned is above is heated by the live steam to the condenser engines, and receives the exhaust from the engine as well as the discharge from the main high pressure cylinder. This system of reheating, the method of handling the condenser exhaust, and the unusual cylinder ratio in the main units combine to secure in these two-cylinder engines economy closely approximating that of the triple expansion engine.

A slate gauge board at each compressor carries gauges indicating the following normal pressures: Steam, 165 pounds; air, 80 to 83 pounds; inter-cooler, 23 to 25 pounds; receiver, 5 pounds; vacuum, 26 inches. A revolution counter is also mounted here, and the daily air output of each compressor is recorded, and checked with the weighed coal and metered boiler feed water.

Each compressor unit has its individual inter-cooler and after-cooler, of vertical type. A 14-inch air header delivers the after-cooler discharge to the primary receiver. A tank in the basement receives the condensation from the entire steam piping system and a pump returns it to the boilers. Condensation from the steam heating system is trapped into the hot well.

The oiling system throughout is automatic and most complete, extending even to the sight-feed lubricators on the pumps. Gravity lubrication of bearings is secured from an elevated tank, the waste oil collecting in a chamber and being passed through an oil filter in the basement to the supply tank above. Each steam cylinder has its individual oil pump, supplemented by a hand-pumping device. The air cylinder oil is carried in a supply tank under receiver pressure, from which it flows by gravity into the high pressure



BOILER ROOM OF THE POWER HOUSE.

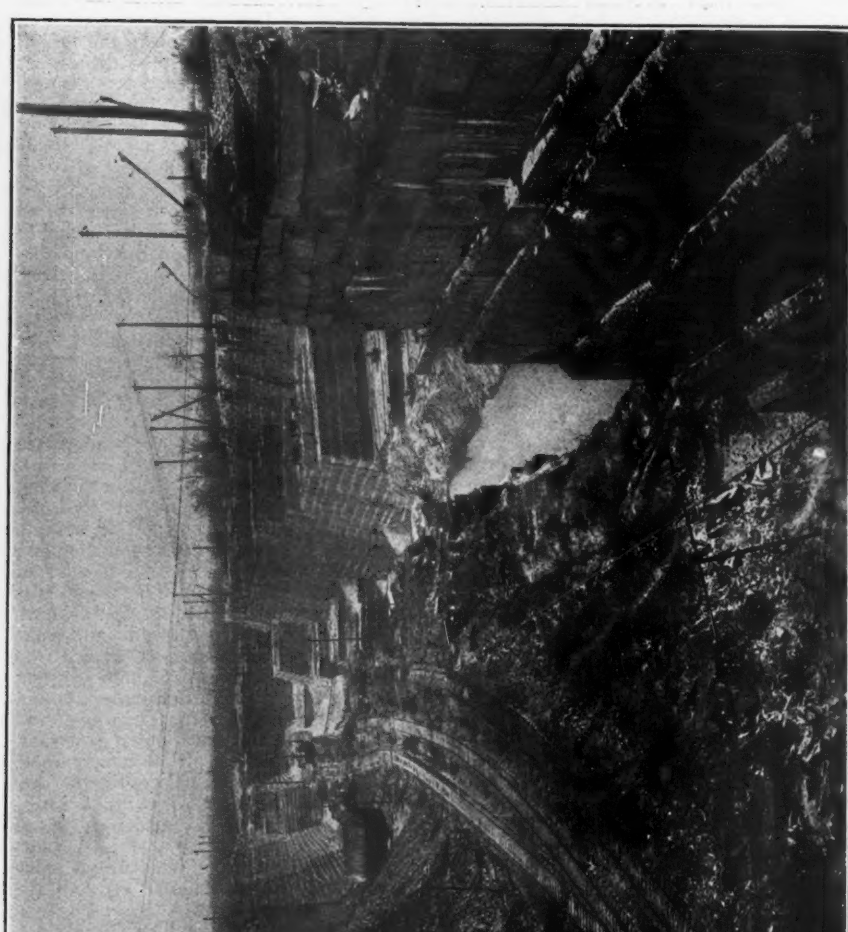
cylinder and high pressure discharge valves. It is delivered to high and low pressure inlet valves, low pressure discharge valves, and low pressure cylinder through reducing valves furnishing pressure suitable in each case. About 75 per cent. of this air oil is recovered in the drains and inter- and after-coolers and is used in the quarry machines.

Outside the power-house, compressed air is distributed and applied to the numerous uses peculiar to quarry work—drilling, channeling, hoisting, pumping, driving gang saw mills, grindstone mills, machine shop, forge fires, etc. As is usual where a new power is adopted, unexpected uses are being found every day.

The removal of the moisture entrained in the compressed air was one of the most vital problems to be solved, as dry air is one of the first requisites in expansive engines. The inter-coolers and after-coolers receive the first and second precipitations of entrained moisture and are regularly drained. The air header discharges into the primary receiver, 66 inches in diameter by 18 feet long, and here again moisture is accumulated and withdrawn through the drain cock. From the primary receiver the air lines grade to secondary receivers. The lines beyond these secondaries are also laid to drain back to them. These secondary receivers catch any moisture which may have passed the earlier separators. In operation it has been found that the air delivered to the cylinders of the machines is remarkably dry.

The air pipe distributing system has been worked out to a fine degree of perfection and as an example of careful engineering is worthy of special note. As the zone of activity in a large quarry is constantly shifting, at any point over a large area, the full power of the system, with a minimum investment for material and minimum liability to vital breakdown in the system. The accompanying diagram shows how this problem has been solved. The air piping has been laid out in a five-loop system and a consideration of the diagram shows that the maximum volume of compressed air is available on any one of the lines, without excessive drop in pressure, while any line or section can be cut out for repair or alteration without crippling any other part of the system. The loop arrangement gives a great carrying capacity at low pipe cost. Expansion and contraction are provided for by off-setting the line one pipe length every 400 feet. These 400 feet sections are anchored at the middle; any variation in the length is taken up in the elasticity of the off-set pipe, without strain to joints or fittings, the line being mounted on rollers at proper intervals. The location of primary and secondary receivers is shown. All valves are of gate pattern and in sizes above 3 inches have rising stems. At intervals of 40 feet 3-inch branch tees are inserted in all mains, for the attachment of branches to working faces. All main line loop tees are protected by valves in their three branches. Whenever air connection to a main is made at a "motion" or working face, a 3-inch riser is brought to the floor level opposite the derrick and connected by a 10-foot length of hose to a 2½ by 2½ by 3 inch tee; branches of the tee are protected by valves and serve for the attachment of a 2½-inch secondary header with 2-inch flanged branches every 6 feet. This header may be extended, flexibility being secured by inserting flexible joints on the laterals next to the header. The hose to each machine ends in a flanged coupling by which it is attached to the header at any of the branch tees. The wear falls upon the threads of bolts, easily replaced, instead of upon the pipe threads, and leaks at these local connections are avoided by this precaution. The air piping system was installed under a guarantee to hold full working pressure for 12 hours, and to stand the same test at the end of a year. The guarantee has so far been sustained. No leaks have been discovered. Air gauges, accurately calibrated and interchanged, have shown no measurable drop in pressure at any point on the distributing system. The ample receiver and pipe capacity absorbs all fluctuations and the pressure maintained at the power-house is available at every working face.

Reheating is employed at hoist and mill engines and is being extended to all air motors. A very simple and effective stationary air reheater has been devised, being a few turns of pipe laid in a brick setting and heated by a small coke fire. The average cost of these reheaters, in labor and material, has been $35. A surprisingly small quantity of coke is required, the cost of present application not exceeding $1 per day. The air is heated to 280 to 300 degrees Fahr., and no trouble has been found in lubrication of cylinders. On some of the channeling machines the



"GRAY CANYON" QUARRY, NORTH AMHERST, O.

old boilers are temporarily retained, connected into the air line and serving as an air reheater by the use of a small coke fire on the partly covered grate. More compact and efficient reheaters are being devised to replace these boilers and for all cases where a portable device is required. No attempt is yet made to reheat the air for the drills.

The only instance of the use of steam for power outside of the main plant is found in Mill No. 1, where eleven gang saws are driven by a 175 horse-power tandem compound condensing steam engine. The location of this mill adjacent to the power-house permitted the operation of this engine at highest economy, with steam from the main boilers, and with the full benefit of expansion secured by connection with the main condensers in the power plant. Mill No. 2, about a half-mile distant from the power-house, contains five gang saws driven by an 80 horse-power engine supplied with air through one of the stationary reheaters described above. Scattered at different points over the workings are five direct-acting plunger pumps, all at present driven by air without reheating, and performing maximum duty. Compressed air is also used in numerous blacksmith forges, in operating the steam hammer, and in driving a grindstone mill in a machine shop. The present aggregate load on the plant, in mill and hoisting engines, channelers, drills, pumps, forges, etc., is about 850 horse-power, while the average combined indicated horse-power of the compressors is at this time about 675. The central boiler plant has replaced thirty-one isolated boilers, aggregating 1,200 B. H. P., which were usually overtaxed. The distributing system is now being extended to supply power to two neighboring quarries about a half-mile south. When these extensions are completed the total number of boilers replaced will be 49, aggregating close to 1,800 B. H. P. So far as possible all these abandoned boilers are piped into the system as local receivers. The power supplied to the two neighboring quarries will be applied to operate a 175 horse-power Corliss engine driving a six gang saw mill, besides seven channelers, six drills, four hoists, three pumps and machine shop and forge fires. A novelty in the distributing mains to these two quarries is the use of light casing with Hammond couplings instead of standard pipe. Natural gas transmission practice has been followed, at a cost for a given carrying capacity of about two thirds that of a standard pipe line.

One of the most interesting features of the installation described is the fact that no special appliances were introduced for the application of the new power. The machinery already operated by steam under the old system was simply overhauled, the cylinders rebored, rods turned, glands packed and clearance reduced, and attached to the air lines. The cut-off on the expansive engines was in some cases shortened to 5/8. Experiments now under way indicate that reheating may be carried to a much higher degree than has yet been attained. It is believed that temperatures as high as 500 to 700 degrees Fahr. may be used, without attaining a mean cylinder temperature which will cause trouble in lubrication. It is believed that in many cases cut-off can be reduced to give terminal pressure at atmosphere. The amount of coke required in reheating is almost negligible. Even with the present reheaters, the cost of reheating fuel for the entire system is less than $1 per day, and as reheaters are developed and perfected still higher fuel economy will be obtained.

The plant was started January 2, 1904, in the midst of a blizzard, with a temperature 15 degrees below zero. Starting under these inauspicious conditions, it has since been operating night and day without shut-down or interruption due to the failure of any link in the system. The two "bogies" which have hitherto frightened all adventurers into the field of pneumatic power transmission—freezing of air engines and low efficiency—have been effectively and permanently disposed of. The successful operation of the plant, without one shut-down or loss due to freezing, shows how effectively this evil has been prevented by the complete elimination of moisture from the compressed air. Reheating is used for its added economy, but the plant has been operated repeatedly under all weather conditions without reheating. The installation of reheating devices has been gradual and is not yet complete. The following figures furnished by the stone company's chief engineer show that the second evil has been removed. The table is a rough comparison of average daily fuel and labor charges against

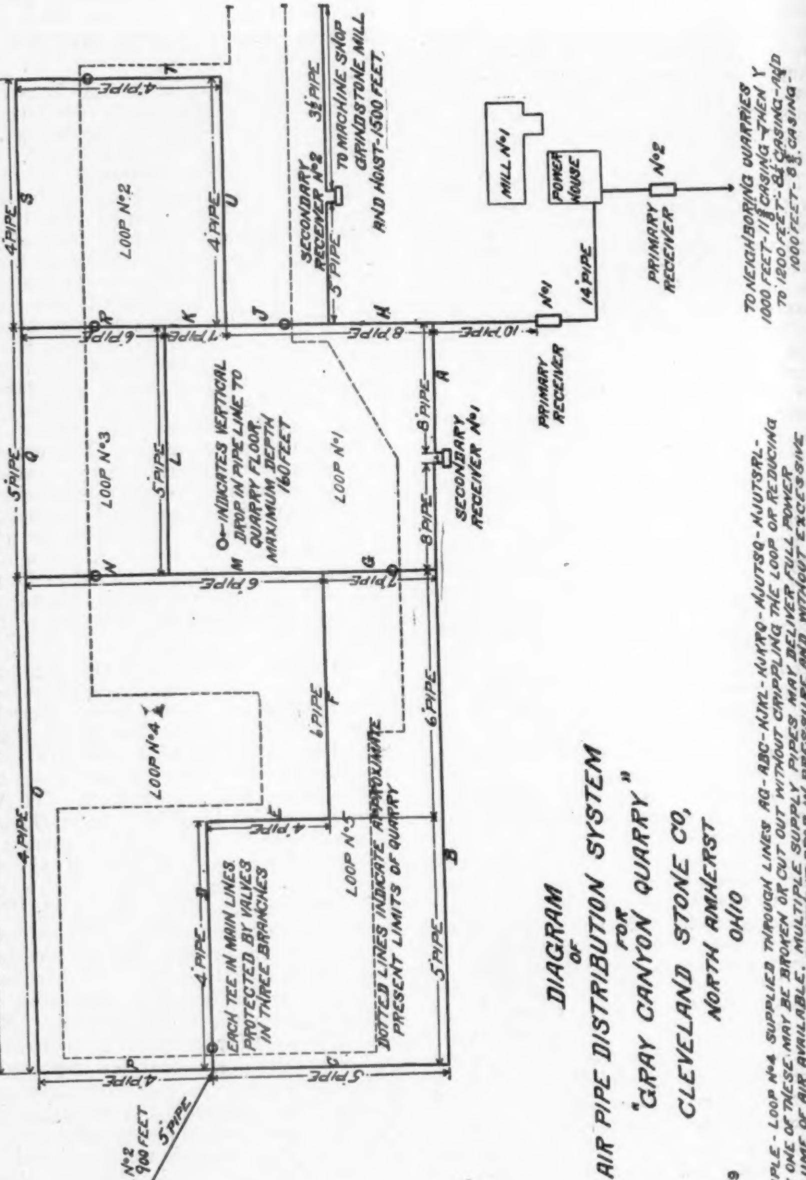


DIAGRAM OF AIR PIPE DISTRIBUTION SYSTEM FOR "GRAY CANYON QUARRY" CLEVELAND STONE CO, NORTH AMHERST OHIO

EXAMPLE - LOOP No 4 SUPPLIED THROUGH LINES AG-ABC-HJKL-HJKRQ-HJUTSRQ-HJUTSRL-ANY ONE OF THESE MAY BE BROKEN OR CUT OUT WITHOUT CRIPPLING THE LOOP OR REDUCING VOLUME OF AIR AVAILABLE. MULTIPLE SUPPLY PIPES MAY DELIVER FULL POWER OF THE SYSTEM TO ANY LOOP WITHOUT DROP IN PRESSURE AND WITHOUT EXCESSIVE FRICTION-

the power system, during the months of April, 1903, operating with steam, and April, 1904, operating with compressed air.

	April, 1903.		April, 1904.	
Coal consumption	50 tons run of mine at $2.00	$100.00	15½ tons slack at $1.60	$24.80
Labor and attendance at channelers	16 machines at $10.00	160.00	12 machines at $10.00	120.00
Labor and attendance at drills	15 machines at $3.00	45.00	9 machines at $3.00	27.00
Firemen at hoists	9 men at $1.25	11.25		
Firemen at pumps and drill boilers	2 men at $1.25	2.50		
Firemen at No. 2 Mill, 12 hour shifts	2 men at $2.00	4.00		
Boiler repair gang		5.00		
Locomotive repair and rental		10.00		
Coke for reheaters				1.00
Total daily charges, labor and fuel		337.75		$172.80

Daily saving in fuel and labor by compressed air, $164.95.

On this basis the total saving in a year of 300 days in fuel and labor is, $49,485.

The reduction in the number of channeling machines and drills operated in 1904, noted in the above comparison, is due to the fact that the heavy and uniform air pressure, always available, enables these fewer machines to do more than the work formerly done by the larger number, when operating under the lower and fluctuating pressure of steam. It is assumed that the charges for oil and waste were the same in both months, an assumption which is not borne out by the facts, which indicate a very great reduction in these charges in 1904. No charges were made in 1903 for the labor and attendance at Mill No. 1, as the same force was required in 1904 at the power-house. The coal consumption is a matter of absolute record. In 1903, run of mine coal was used, delivered to 31 boilers, and broken, scattered and wasted in cartage. In 1904 slack coal was handled at minimum cost. The item of boiler repairs is based upon the fact that under the old system, with isolated boilers and local water, one boiler-maker and assistant were constantly retained to keep these boilers in repair. Prior to the introduction of the compressed air plant, the company's locomotives were out of commission one month in the year, undergoing repairs and general overhauling. During this month the company was compelled to rent other locomotives from the railway. This rental, together with the cost of repairs, brought the average daily charge against this machine to $10. Under the present system the locomotives draw their feed water from a tank supplied from the purifying system in the power-house. Their boilers are now perfectly clean inside and to date no charge has been made against them for repairs.

Another fact worthy of note is that the steam plants replaced by the new system were in most cases operating under conditions of average fuel and steam economy. The boilers at the hoists were of good tubular type, in standard brick settings and well housed. The steam pipes to the engines were in no case more than 15 feet long. The same conditions existed at Mill No. 2. The channelers carried their own boilers, of standard locomotive type, and the steam pipes were not over 6 feet in length. About 85 per cent. of the steam used is accounted for by these boilers. Yet even with these favorable conditions of fuel economy, the saving on coal consumption has been as indicated in the table above.

This tabulated comparison is a statement of fact, but it fails to bring out two points, of vital importance; the output of rock in April, 1904, was much greater than in April, 1903, and this increased output was secured with the total labor force reduced over that of 1904 by about 75 men. Figuring these men at the average daily wage of the quarrymen, the daily saving just shown is brought up to about $275. This result is due to several causes, chief among which is perhaps the fact that a full working day of ten hours is secured under the most effective conditions. When the whistle blows the full working pressure is secured at the turn of the throttle and is maintained throughout the day. There is no delay at starting. There is no fluctuation in pressure due to care-

less boiler attendance. There is no labor employed in wheeling coal and in moving water barrels and pipe to keep pace with the movement of the channelers. There is no smoke and steam settling in the quarry, darkening it, making a short day shorter and interfering with rapid hoisting. There is no steam to wet the clothing of the men in cold weather, no smoke and heat to stifle them in warm weather. There is no condensed steam in the pipes and cylinders to be blown out before operations begin. There is no draining gang to empty the pipes at night, no thawing gang to open them in the morning. There is no time lost in banking fires or waiting for coal. Heavy air pressure, everywhere uniform, drives every machine to the limit.

Furthermore, the use of the new power has improved the character of the quarry output. Under the old system, with coal and ashes scattered over the working floors, the water from rain or snow found its way through the coal or ash pile, over the surface and down the sides of the rock, staining and discoloring it. With smoke from the boilers filling the quarry, the exposed faces were quickly covered with a dark deposit. Since air has been used, these effects have disappeared, and the rock quarried presents a clean, sparkling surface.

The introduction of compressed air has made conditions so pleasant that old men are eager to remain and the best class of new labor is attracted. A stimulating effect is felt by the entire working force and there is noticed a vim and push and cheer which was not present under the old arrangement. The value of these features cannot be stated in dollars and cents, but it is certain to run into the thousands in the course of a year.

The plant was installed under a most rigid guarantee of fuel consumption; it being guaranteed to furnish air to operate the machines at that time maintaining the quarry output with a daily consumption of coal not to exceed 17 short tons. The guarantee has been more than sustained under daily working conditions established without formal test. The average daily consumption of coal, as shown above, was in April last 15.5 short tons.

A feature of special interest is the fact that in operating the plant there has been found to be no appreciable "peak load" during the day. The compressors maintain almost a uniform output. Fluctuations in load are small and gradual. The explanation of this lies in the immense storage capacity secured in primary and secondary receivers, in the pipe line itself and in the old boilers which have been connected in auxiliary receivers at different points on the system. This steady load is in great contrast to the daily load on an electric power distributing system, where no storage capacity can smooth out the irregularities in the load curve. Another most interesting development has arisen in the operation of the main units. While the present load on the system is well within the capacity of one compressor, it has been found that the consumption of coal is no greater when the load is divided between the two units than when one compressor furnishes the entire output. In other words, it has been found just as economical to operate the two main units in parallel at about 30 revolutions per minute as to run one at 60 revolutions. As stated earlier, the normal rated speed of the compressors is 90 revolutions per minute, but they are found to have the same efficiency when underloaded as when fully loaded at rated speed. A number of conditions combine to bring about the result.

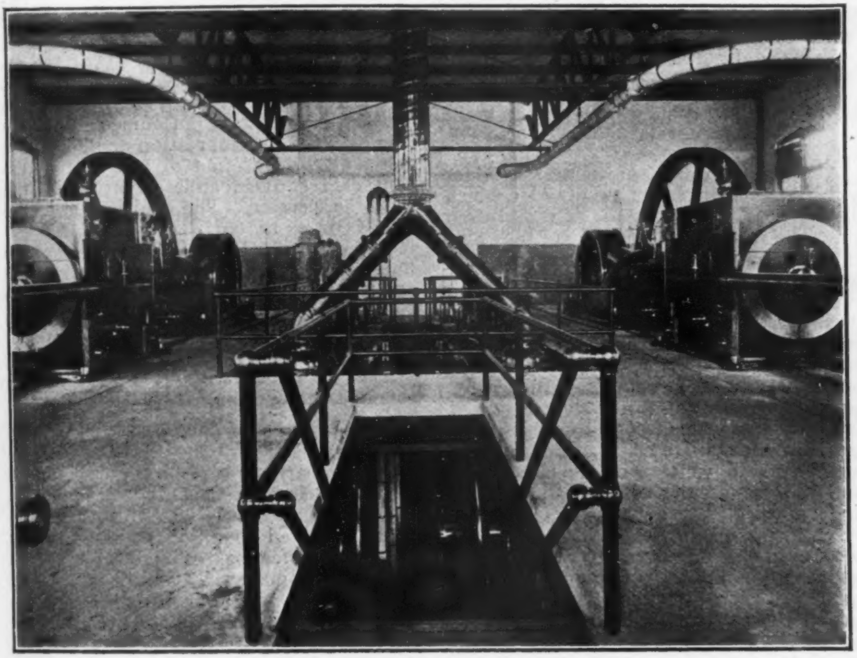
In the steam end of the compressor the losses by radiation, inherent in the steam engine, are greater at slow speed than at high. A low piston speed allows the steam to remain during a longer period in contact with the comparatively cool cylinder walls, resulting in a greater condensation —a loss which is, however, somewhat recovered by re-evaporation at the end of the stroke. Low steam velocity also permits greater condensation in the steam piping. On the other hand, in a compressor the load per stroke on the pistons is practically constant. As noted earlier in this article, the air pressure is maintained constant by varying the speed of the compressor, this variation being secured through the pneumatic governor by changing the cut-off, but it is noted that as soon as normal pressure is reached, the cut-off is restored to about normal value, while the speed remains proportional to the load. This means that the steam end is operating all the time at cut-off of practically maximum economy.

In the air end of the compressor, light load and low piston speed means that the air during the process of slow compression

is in contact with the cylinder walls, and consequently subject to the jacket cooling action, during a longer period. The cooling water is more effective in removing the heat of compression, a given volume of water being required to absorb a smaller quantity of heat. These conditions result in nearly isothermal compression and the indicator cards from the air cylinders of these machines show a compression line closely approximating the isothermal.

The friction load on the compressor unit is proportional to the speed. A consideration of all of the above items on both sides of the account shows a balance between conditions in the air and steam ends of the unit resulting in efficiency practically uniform at all loads.

A parallel consideration of the steam driven electric unit shows the disadvantage under which it must operate. A constant speed must be maintained, meaning a constant maximum friction load. The engine operates at most economical cut-off only at full load. When underloaded, it uses shortened cut-off, meaning excessive expansion and a lower mean cylinder temperature, with increased condensation loss. Not only is the steam engine operating at lowered efficiency under light load, but the same is true of the generator. The total efficiency of the unit is the product of these reduced efficiencies, and diminishes with the load.



VIEW OF ENGINE ROOM OF THE POWER HOUSE.

There is at present being introduced in the works at North Amherst a system of record and cost keeping which will charge against each department of the plant its individual expense, and show the cost of each productive operation. When the distributing system is extended to the south quarries—not contemplated in the original scheme—a detailed test is to be made

along approved lines of engineering practice. When the test has been made and its results worked out in connection with the recorded productive costs, a comprehensive statement of the operative economy of the system can be made. Such parts of this statement as would be of interest to the engineering public may appear later in these columns.

The plant was designed and installed complete for the Ingersoll-Sergeant Drill Company, of New York, under personal supervision of Mr. George R. Murray, Manager of the Cleveland and Pittsburg offices of that company.

LUCIUS I. WIGHTMAN, E. E.

Caisson Illness and Divers' Palsy; An Experimental Study.*

A caisson consists of a steel cylinder which is sunk in water, and out of which the water is kept by means of compressed air. The men in the caisson are thus able to work on the bed of the river or the sea.

The top of the caisson is provided with an air-lock, a chamber fitted with air-tight doors and cocks, whereby the air can be compressed or decompressed as the men enter or leave. A large cock is utilized for rapid decompression during the passage of material, and a small cock for the slower decompression of men. The men frequently take advantage of the large cock, and by breaking the rules get out of the air-lock quickly.

Ten metres of water roughly correspond to 1 atm.; thus, for every 10 metres or 33 feet a pressure of + 15 pounds to the square inch or + 1 atm. is required to keep the water out of the caisson or diving bell. At a depth of 100 feet a man would be exposed to + 3 atm., at 200 feet to + 6 atm. In the case of a diver the conditions are the same. Compressed air is delivered through a tube to his helmet and escapes by a valve, by which means the water is kept out of his dress. The pressure of the air must always be just greater than that of the water.

The numerous accounts of caissoniers' and divers' sickness which have been published show that the sickness never attacks the men while under pressure, but only after decompression. The account of the symptoms given by Pol and Watelle in 1854 may be taken as typical. These authors had charge of 64 men who were employed in a caisson on the banks of the Loire at + 3¼ atm. The men were compressed in 15 minutes, worked for a four-hour shift, and were, according to the rules, decompressed in 30 minutes.

The physiological effects observed in compressed air were very slight: pains in the tympanic membrane (relieved by opening the Eustachian tube); slowing of respiration and diminution in thoracic expansion; slowing of the pulse; increase of urinary secretion; a feeling of resistance to movement owing to density of the atmosphere; inability to whisper, attributed to the resistance of the compressed air to the finer muscular movements of the tongue. On decompression these authors felt a lively sensation of cold and a certain degree of breathlessness; while the pulse accelerated. The cold is due to the expansion of the air.

Pathological effects: There were 47 men out of the 64 who stood the work more or less well; 25 were discharged owing to sickness; 2 died. The slighter attacks were 14, and the serious attacks 16 in number.

The accidents without exception occurred after decompression.

TYPES OF CASES.

(1) Embarrassed respiration, pains in the limbs, loss of appetite and digestive troubles, black stools, loss of flesh.

(2) A dazed condition, muscular pains and cramps, feelings of numbness, vomiting of black material. One day this man lost consciousness soon after decompression. The pulse was full and frequent, the face congested, the respiration short and stertorous with mucous rales. There was complete loss of muscular power. The man was bled, purged and blistered and recovered in four hours.

(3) Severe muscular pains with cramps, the skin cold, respiration embarrassed, the pulse small and slow.

(4) A comatose condition like to drunkenness, with indistinct speech, dilated pupils, accelerated respiration and rapid pulse. Diplopia, deafness and vertigo persisted.

(5) Severe pain in the limbs and chest, embarrassed respiration. The man was discharged. He returned to the work without permission. On decompression

* Abstract of an article in the *Journal of Hygiene* by Leonard Hill, M.B., F.R.S., and J. J. R. Macleod, M.B., as published in the *Engineering News*.

he suddenly fell unconscious and died in 15 minutes.

(6) Great oppression, with dullness and bronchophony, a rapid pulse, cold skin, continual cough, and cloznic contractions of the limbs. Better after 5 hours of care. On another occasion this man became comatose, with dilated pupils, loss of muscular power and subdelirium. He was bled; the venous blood was arterial in color. The man recovered and was discharged.

(7) Vision disturbed and double, hearing abolished, respiration frequent, pulse frequent and high tension. Bled, venous blood arterial in color.

(8) Pains in the head, vertigo, cramps.

(9) A powerful man, aged 40. Died immediately after decompression.

(10) Muscular pains. Cured by recompression.

(11) Very severe muscular pains, persisting for many days.

(12) A few minutes after decompression the man appeared to be dead; unconscious, livid face, dilated pupils, embarrassed respiration, indistinct trembling of the heart, no pulse, involuntary micturition, black vomit. Given hot baths and massage. Pulse returned in 30 minutes. Very severe muscular pains, blindness and deafness, with a wretched pulse during the night.

Next day the man is better but mentally confused. He recovered, but feeble vision and dilated pupils persisted.

Pol once suffered himself from acute pain in the left shoulder or arm, with shivering and vomiting. It seemed to him that emphysema existed in these places. E. H. Snell likewise thought he could detect emphysema in one of the cases, of joint and muscular pain ("bends" or "la pressure") at the Blackwall Tunnel; while Bucquoy records that a cupping-glass, applied by a skilled assistant, would not hold on to a painful knee-joint owing to the gas set free in the subcutaneous tissues.

Among the numerous other reports collected together by Paul Bert and recently added to by E. H. Snell, we will quote some cases recorded by Babington and Cuthbert at Londonderry. The pressure reached 30 to 43 pounds.

As in all caisson works the men suffered joint muscular pains or from "bends."

Cases.

(1) The man suddenly fell unconscious on decompression after 4 hours at 28 pounds. He was cold and livid. There was right facial paralysis and strabismus; pupils immobile. Pulse, 150, small and irregular; heart sounds almost inaudible; respirations, 24 to 44, very irregular. Bled; blood very black. Died in 24 hours.

(2) Similar to (1) but no facial paralysis.

(3) Sharp shooting pains in legs and thighs; unable to walk, feet cold and numb; legs anaesthetic; was found with feet almost in the fire and toes badly burnt. Recovered in two days.

(4) Very similar to (3). Recovered in a few days.

(5) Fell helpless and semi-comatose during decompression. Could be roused to answer questions. Coma passed off in 18 hours. Totally paralyzed from fourth rib; retention of urine. Died 160 days after.

(6) Similar to (5), but paralyzed from eighth dorsal vertebra. Died after 30 days.

In sinking the foundation of a bridge at St. Louis, on the Mississippi, a high pressure of + 50 pounds was used. The number of workers was 600, of whom 14 died and 119 were more or less affected. On leaving the caisson the workers are stated to have been pale and fatigued. Involuntary contractions and nose bleeding occurred in some.

As the depth increased the illnesses became more numerous and severe. The men were not taken sick while in the caissons, but a few minutes to one hour after decompressions. At the greatest depth the shifts were reduced from 4 to 1 hour, and the engineer, Eads, states that this reduced the serious accidents to nil. Visitors who stayed but a few minutes, and the workers of the locks, who were quickly compressed and decompressed, never suffered. Fifty-three cases suffered from paralysis of the legs with, usually, epigastric pain. Nearly all these recovered in from one day to one week. The sudden deaths were preceded by coma, stertorous breathing and muscular spasms.

At Brooklyn Bridge 110 similar cases of illness occurred, with three deaths, as reported by Dr. Andrew Smith. J. Hunter stated that at the Forth Bridge works "the joint pain is of all symptoms the most constant, and almost invariably it at-

tacks the knee alone, or with other joints, rendering its poor victims from its severity absolutely helpless * * *. Another prominent symptom met with was epigastric pain accompanied by vomiting."

The following interesting case is reported by Dr. Turgman in the files of the *British Medical Journal* for 1888. A man worked for 3 hours at + 60 pounds. He was decompressed in 3 minutes. On the way home he was seized with severe pain in the right elbow joint, a little later his right knee gave under him and he fell and became semi-conscious. Acute pain in both elbows and knees followed and 6 hours after decompression he was found cold and almost pulseless. He recovered but spat blood for 3 or 4 days. Necrosis of the right femur followed and the leg had to be amputated. The cause of this was, no doubt, embolism of the medullary artery of the femur.

The following account given by one of the caissoniers in the Blackwall Tunnel gives a graphic picture of the less grave form of accidents:

"What did it feel like to go in? Oh, just the same as anywhere else. You felt a wee bit giddy when you went in, that was all.

"We stayed in for eight hours at a shift. We had half an hour for dinner, but some of the men would not come out for it. They took it inside with them. Coming out again it was not so bad, but just chilly; bitter chilly, cold as charity. The pains would come on afterward, in an hour or so, or when you got into bed. Bends in the back, and the wrists, and the legs; just awful. Men would turn out in the middle of the night and come back to the works and get into the compressed air again in the medical locks. They had a full dose of it for a start, and let the pressure drop gradually. Then they went back home to bed. Do them any good? Eh, mon, it's no for me to say. They said so, but I thought it was only humbug, a faith dodge. When I had bends I just jumped about and took a drap of guid whuskey—better than all your doctor's concoctions.

"I never felt happier than when I was in the compressed air. Always happy, and on the cherry side. Why, laddie, I would get up in the morning feeling very dour and queer, and just go into the workings, and then whistle and sing all day long. Not that you could hear the whistling, at least a man with my lungs, when the pressure was over twenty-five.

"The worst thing that could happen was for the electric light to fail. Then they burnt candles, and the mixture of smoke with the air gave them 'bends' of an extra special vigor. (He was in the No. 3 caisson, where the pressure was as high as 37 pounds to the square inch. The effect of that abnormally condensed atmosphere was to cause an overpowering sleepiness.) You nodded and didn't care if you went to sleep forever, though it was all very nice and dreamy. When I was alone in that 'casoon' I had to rope myself up lest I should fall asleep and tumble to the bottom, 60 feet below. It was better under the river than in the 'casoons,' because under the river the air could escape into the Thames. Tobacco had no sting. Even Irish roll had lost its savor. The only stuff that had any flavor was four-ale. You weren't allowed to take it in, but you did. But you had to take the cork out first. If you didn't the bottle would burst. The finest men in the tunnel were the first to be knocked out. The men of delicate appearance stood the pressure best."

The symptoms of the men employed at Blackwall have been fully reported by E. H. Snell (loc. cit.). Snell especially brought into notice cases of auditory vertigo.

In none of these cases the vertigo occurred without deafness. The vertigo was increased by moving the head in one particular direction and was frequently accompanied by vomiting and mystagmus.

That very prolonged exposure to compressed air is harmless is shown by the fact that mules were kept in the Hudson caissons (at + 2.3 atm.) for many months and were sold for a good figure at the end (E. W. Moir).

Von Schroetter has studied many caisson cases at Vienna where the depth of the water was 25 meters. In one case a strong, healthy man, aged thirty-six, worked at + 2⅓ atm. for the first time from 10 P. M. to 2 A. M. without any trouble. Half an hour after his ascent he was seized with intense pains in the limbs, with great difficulty in breathing. He soon could not stand and lost consciousness. There was now great dyspnoea, an intermittent pulse, cyanosis of the face, and fine rales over the lower lobes of the lungs.

The face became livid, the pulse almost imperceptible. After ether injections and artificial respiration consciousness returned. The patient complained of great pain, and especially in the right arm, and of feeling cold. He could not move. Temperature 36 degrees C. Profuse sweating. The respiration was cartal and the diaphragm fixed in the expiratory position. The man gradually recovered, but two months later there was still some loss of motor power, patches of hyperalgesia, increased knee jerks, pains in right elbow and left knee, loss of sexual power, and inability to hold urine more than one hour. There was evidently a lesion above the origin of the phrenics in this case, producing the immobility of the diaphragm and arm symptoms. Probably there was another lesion in the lower dorsal region.

Cases of Diver's Sickness.—In the case of diver's sickness a large number of reports have been gathered together by Bert. M. Denyreuze, reported on 200 men who dived to a pressure of + 3 to + 4 atm. During six months' work five men died and a great number were affected, most commonly with paralysis of the legs and bladder and deafness. The men who quickly returned to the surface suffered most. None of the deaths occurred while the men were under water. M. Gal recorded the following typical cases occurring among the Greek divers:

(1) Submerged for 15 minutes, at 40 to 45 meters (+ 4 to 4½ atm.). Some minutes after returning to the boat the diver complained of dizziness and fell down and died.

(2) Submerged for 45 minutes at 40 meters; 15 minutes after being pulled up he was seized with pains, and almost at once lost consciousness and died.

(3) Thirty minutes after return to the boat was seized with severe pain in the epigastrium. Became paralyzed in legs, bladder and rectum. Died after three months.

(4) Became paraplegic shortly after return to boat. Cured in three months.

(5) Depth 35 to 45 meters; paralysis of legs; cured in five days.

Messrs. Siebe and Gorman tell us that among the Greek divers about a score of lives are lost every year.

Through the agency of Messrs. Siebe and Gorman we circulated among the pearl divers of Australia questions concerning the illnesses of divers. The divers there go to 100 feet and very rarely to 125 feet. In shallow water they work for two hours, in deep water for 15 to 20 minutes.

The symptoms of illness occur directly or soon after the diver comes on deck. There is no pain whilst on the bottom but directly the diver comes to the top. The pains occur in the hips and knees, the calves of legs and arms. Paralysis of the leg and incontinence of urine are graver symptoms.

The following are extracts from the records of the autopsies which have been made after deaths due to caisson illness and divers' paralysis.

Autopsies of Caissoniers.

(1) General congestion of the viscera, patches of congestion on the brain.

(2) General subcutaneous emphysema. Congestion of viscera and especially of lungs. A heavy man, aged forty. (Pol and Watelle.)

(3) Interlobar emphysema of lungs, numerous punctured ecchymoses on the pleura and pericardium, bubbles of gas within the blood vessels. Death from bursting of caisson. (Gallard.)

(4) Softening of some inches of the spinal cord in the dorsal region. (Bert.)

(5) Extravasation of blood upon the spinal cord opposite the two lower dorsal vertebrae. (A. Smith.)

(6) Extravasation of blood upon, and softening of spinal cord, hemorrhages in the kidneys. (Jaminet.)

(7) Death 15 days after decompression. Numerous foci of hemorrhages and signs of acute myelitis. Small, irregular fissures in mid-dorsal cord filled with round cells. From their well-defined edge probably produced by escape of gas. (v. Leyden.)

(8) Death 2½ months after decompression. Disseminated myelitis in dorsal region with fissures suggesting laceration of the tissues. (Schultze.)

(9) Death on third day. Fissuring and laceration of spinal cord. (Ziegler's Beitrage, 1892.)

Autopsies of Divers.

(10) Hemorrhages in or upon spinal cord. (Gal, Greek divers.)

(11) Hemorrhages in or upon spinal cord. (Blick, Australian pearlers.)

Theories of Compressed Air Illness.

The phenomena observed in local compression of the body and in cupping, the pallor of caissoniers, the nose-bleeding

sometimes seen on decompression, the congestion of the viscera recorded in a few autopsies, have led most medical men who have observed caisson sickness to suppose that the blood is driven from the exterior and compressed within the viscera.

"Pulmonary and cerebral congestions are," say Pol and Watelle, "the chief results of compressed air. Just as a lowered atmospheric pressure brings blood to the exterior and causes hemorrhages, so does compressed air congest the viscera." The brain and spinal cord, according to Babington, shut up in their osseous cavities, are not able, like other elastic parts, to quickly accommodate themselves to changes of pressure.

Bouchard put forward the extraordinary theory that as the gases of the intestine are compressed and abdominal wall becomes concave, and as the abdominal wall resists this distortion, it converts the abdomen into a kind of cupping-glass. This leads to congestion of the abdomen during compression, and the reverse on decompression.

A. H. Smith may be quoted as the chief exponent of the mechanical congestion doctrine. He deduced "the law that under high atmospheric pressure the centres will be congested at the expense of the periphery * * * and that firm and compact structures will be congested at the expense of those more compressible. Moxon, in his Croonian Lectures, said "it needs no experiment to show that great increase of atmospheric pressure must drive the blood away from the surface of the body."

The neglect by these writers of physical laws is the less excusable, seeing that Poisseuille in 1835, observed the capillary circulation in frogs, and young mice, inclosed in a glass chamber and submitted rapidly to + 2 to + 8 atm. The circulation continued unaffected. Moreover, Paul Bert, in 1881, clearly stated the physical error contained in such theories. The body of a workman exposed to compressed air supports, according to Guerard:

at + 1 atm. an additional 15,500—20,600 kilograms;
at + 3 atm. an additional 46,500— 60,800 kilograms;
at + 6 atm. an additional 93,000—123,600 kilograms.

If it were not for the incompressibility of the fluids of the body, and the equal and instant distribution of the pressure to all parts, life would be impossible under any variation of atmospheric pressure. The fact that mere mechanical pressure is of no importance is shown, not only by Guerard's figures, but by the existence of abundant life in the sea at depths of 2,000 meters, corresponding to a pressure of + 200 atm. The only mechanical compressions which can take place are that of the membrana tympani, which is relieved by opening the Eustachian tube, and that of the intestinal gas. The latter leads to the workmen tightening their belts and to a freer descent of the diaphragm in respiration. It has astonished us to find the most experienced practical men in diving and submarine engineering unaware of the experimental work of Paul Bert, of the conclusion which he drew as to the causation of compressed air illness, and of the precautions which he laid down for the guidance of caisson workers.

Paul Bert, by his remarkable experiments, published in 1878, proved that the true cause of caisson sickness is the effervescence of gas in the blood and tissue juices. This explanation had, it is true, been advanced by several authors, such as Hoppe (1857), Francois, Rameau, Bucquoy, etc., but generally as a cause additional and subsidiary to mechanical congestion.

Bert found by analysis of the gases of the blood that the nitrogen increases in compressed air more or less according to Dalton's law. He found that this gas was set free on rapid decompression, and produced embolism, in the lungs, the central nervous system, etc., and that the gravity of the result depended on the height of the pressure, the length of exposure, and the rapidity of decompression. He also proved that the gas set free in the tissues might produce local swellings and emphysema.

The truth of Bert's explanation is borne out by the varied nature of the lesions found in caisson sickness, by the subcutaneous emphysema which has been detected in a few cases, and by the autopsies which have been recorded. One man is struck with pain in the joints and muscles, and another with respiratory embarrassment and loss of consciousness, another with deafness and vertigo, and yet another with paraplegia.

All becomes clear if the cause is once accepted to be local embolism or compression by air bubbles. Thus air bubbles in

the posterior roots or posterior columns of the spinal cord may cause the intense pains so often experienced. Air frothing in the heart may kill one man, air in the heart or in the vessels of the lung, or in the respiratory nervous system produce in another difficult breathing, air embolism in the brain may cause loss of consciousness or sudden death, or in the dorsal cord render paraplegic others, while a bubble in a semicircular canal will explain the cases of auditory vertigo, and bubbles in the joints and muscles cause local swellings and emphysema coupled with pain. Bert also found that high oxygen tension acts as a general protoplasmic poison arresting metabolism, depressing the body temperature, and causing the discharge of convulsions in mammals, and finally the death of all forms of life.

Since the publication of Bert's results little experimental work has been done on the subject. The most important paper is one by Lorrain Smith, who has found that high oxygen tension produces inflammation of the lungs. During the last few years we have been reinvestigating the effects of compressed air and oxygen, and we propose to communicate the results obtained so far, under the following headings:

(1) Effects on the respiratory exchange and body temperatures.
(2) Effects on the nitrogen output.
(3) Effects on the lungs.
(4) Effects on the neuro-muscular system.
(5) Effects on the central nervous system.
(6) Effects on the blood gases.
(7) Effects on the circulation.
(8) The effects of decompression.
(9) The rules of safe working for caissoniers and divers.

Effects on the Respiratory Exchange and Body Temperature.

Bert inclosed animals in a small air-tight chamber and exposed them to increased pressures of air or oxygen. The chamber was not ventilated, and the animals were left till they died, when the air in the chamber was analyzed.

We have studied the respiratory exchange in animals placed in a pressure-chamber and ventilated with a current of air or oxygen. The chamber was fitted with thick glass windows and a pressure-gauge. It was connected by an inlet tube with a bottle of compressed air or oxygen (Brin's), while an outlet tube, controlled by a screw tap, was connected with a set of Haldane-Pembrey absorption tubes and a gas meter. The outputs of CO_2 and H_2O were obtained by weighing the absorption tubes. The animals were given a wool bed to prevent their losing heat directly to the metal walls of the chamber, and the chamber in some cases was heated on a sand bath, and the temperature of the outgoing air taken.

In the *Journal of Physiology* (XXIX., p. 492, 1903) we have published examples of the results we have obtained from mice. We concluded that compressed air at a pressure of + 4 atm. and upward diminishes the CO_2 output and lowers the body temperature of mice. This effect generally increases as the pressure rises, but the individual power of resistance differs greatly in different animals. Paul Bert says that the absorption of oxygen and elimination of carbonic acid diminish in proportion as the tension of oxygen rises, and that an animal breathing pure oxygen at 2, 3, 4 atm. is in the same condition as another breathing air at pressures of 10, 15 and 20 atm.

We have also observed, with the microscope, the capillary circulation in the frog's web and bat's wing, the animals being placed in a chamber fitted at either end with glass windows. The web or wing was spread over one window and illuminated with the arc light. We could detect no change either in the calibre of the blood vessels, or the rate of flow, when the pressure was quickly raised to + 20 to 30 atm. Neither did any change occur on rapid decompression, that is, until gas bubbles frothed off from the blood.

These experiments prove, then, once and for all that the pressure has no mechanical effect on the circulation, and they overthrow all the mechanical congestion theories of caisson-illness.

Effects of Decompression.

Out of 24 dogs exposed by Bert to 7 to 9½ atm. and then rapidly decompressed in one to four minutes, 21 died from the setting free of gas in the blood and tissues and only one escaped without symptoms.

Out of three cats exposed to 0.8 atm. and decompressed in two to three minutes, one died in 15 minutes, and the other two became paralyzed with softening of the spinal cord.

(*Continued in August Issue*)

A New Vacuum System for Pneumatic Transmission.

The salient feature of the system illustrated is that the line is normally a sealed partial vacuum, air being admitted only when the cartridge or carrier is in transit, instead of flowing continuously, as in the older systems; in other words, power is used only when the apparatus is actually in use. The system is based upon the Dinspel-Stoetzel patents and is designed not only for cash carrier service in stores, but also on a more elaborate scale for the transmission of mail freight and express matter underground. The engraving in Figure 1 shows a typical station of a store system. At the left, upon the cabinet, are shown variations of terminal appliances. At the right is the complete apparatus as installed for service with pipes overhead. Beneath the table is shown a cylinder, within which is contained the ram, acting as a timing device. For each station this ram is so adjusted as to close the line immediately after the cartridge has reached its destination. The operation of the system is briefly as follows:

The air pumps connected with the system operate to exhaust the air from the pipes, which, as already indicated, are nominally sealed at both delivery and receiving ends against the entrance of exterior air. The pumps are controlled by governors set to stop their operation when the desired degree of vacuum is reached. The lower end of the ram cylinder is in pipe connection with the sending tube, so that normally the underside of the ram is in communication with the partial vacuum of the system, while the upper side of the ram bears atmospheric pressure. Under these conditions the ram remains at the bottom of its cylinder. The insertion of a cartridge into the end of the sending tube depresses a trigger, which reverses the condition of affairs at the ram cylinder, admitting air underneath the ram and placing the upper end of the cylinder in connection with the vacuum system. Under these conditions the ram rises, and, by means of its rod connection, mechanically opens a valve at the switch or crossover, about 8 feet above the table. The opening of this valve places the lower portion of the tube in connection with the vacuum system, so that the atmospheric pressure back of the cartridge forces it upward past the valve and thence through the system to its destination. As soon as the cartridge has passed the valve normal conditions at the ram cylinder are gradually restored, so that the ram descends to its lower position. This return of the ram is so timed by the relative diameters of inlet and outlet pipes that its descent will allow the valve in the pipe above to close when the cartridge has been transmitted to its destination.

The diaphragm governor, controlling the action of the air pump, is arranged to start and stop the latter only as the conditions throughout the system require. When a cartridge is inserted into the sending tube a flood of air is let in, filling the pipe behind the carriage and driving the carrier through the pipe. This breaking of the vacuum in the tube system, with which the upper side of the diaphragm is in communication, results in depression of the diaphragm by the tension of a helical spring, automatically starting the pump into operation. As the air in the system is again gradually rarefied, including the governor space above the diaphragm, atmospheric pressure at the vents below the diaphragm again overcomes the tension of the spring constantly exerting its force to draw the diaphragm downward, restores the diaphragm to its upper position and stops the pump.

In ordinary store service the system is worked on the basis of a rarefaction of about 1¼ pounds per square inch below atmospheric pressure, commonly spoken of as "1¼ pounds vacuum." By strengthening the spring of the governor diaphragm and increasing the pumping capacity this rarefaction may be increased to any reasonable desired amount. The diaphragm governor, while designed particularly for use in the present connection, may be used as well for controlling the operation of steam engines, gas engines or electric motors, or for shifting belts.

LONG DISTANCE UNDERGROUND SERVICE.

For long distance underground systems the same principles as those for store service are involved, but for the sake of economical operation transmission lines are divided up into relay sections of from 1 to 3 miles in length. In an elaborate system, sending and receiving tubes of various diameters may be grouped together, the smaller tubes for mail, telegrams, etc.; the larger ones for freight and express matter up to, perhaps, 500

pounds per carrier. Beneath this transmission tube system must be placed a large pipe of a sectional area equivalent to the sum of the sectional areas of the and speed of transmission desired—is connected with each of the service tubes.

Figure 2 shows the essentials of a complete system of this type, including one

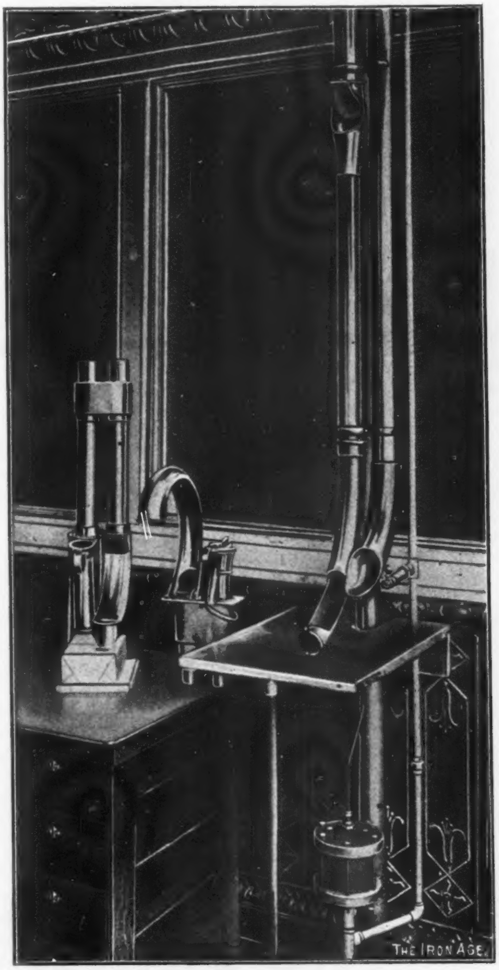


FIG. 1.—STORE SERVICE APPARATUS. A NEW SYSTEM OF PNEUMATIC TRANSMISSION.

service tubes. This large pipe is connected with the pumps at the power house, and, at intervals of from 1 to 3¼ miles—according to the diameters of the tubes relay station. For longer systems the section marked "relay device" would be repeated alternately with long sections of transmission tube. The essentials of the

system, then, are the transmission device and the terminal device, connected by transmission tubes of suitable lengths, each leading to a relay device. At the right hand of Figure 2 is the receiver trough, having a hinged cover which may be lifted to admit the carrier. The end of the trough and cover are perforated with holes to admit the exterior air for starting the carrier when the gate valve between the receiver trough and the transmission tube is opened. The operator,

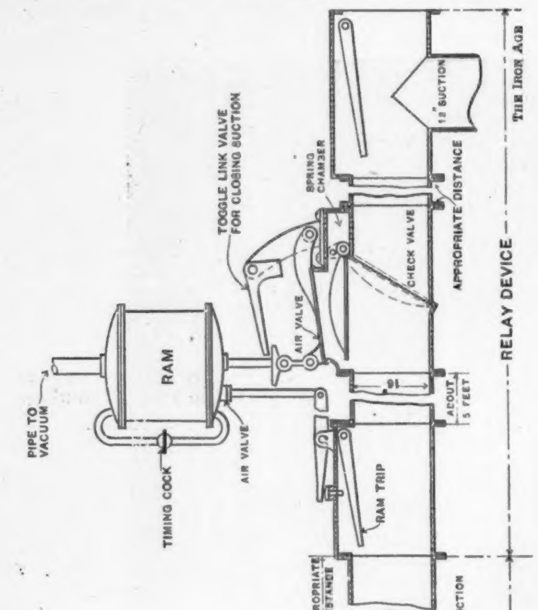


FIG. 2.—TRANSMISSION TUBE AND OPERATING APPLIANCES FOR RELAY SYSTEM OF LONG DISTANCE CARRIAGE.

having inserted the carrier and closed the receiver trough, throws downward the starting lever above, after which the action of the system for transmission and delivery of the carrier is entirely automatic.

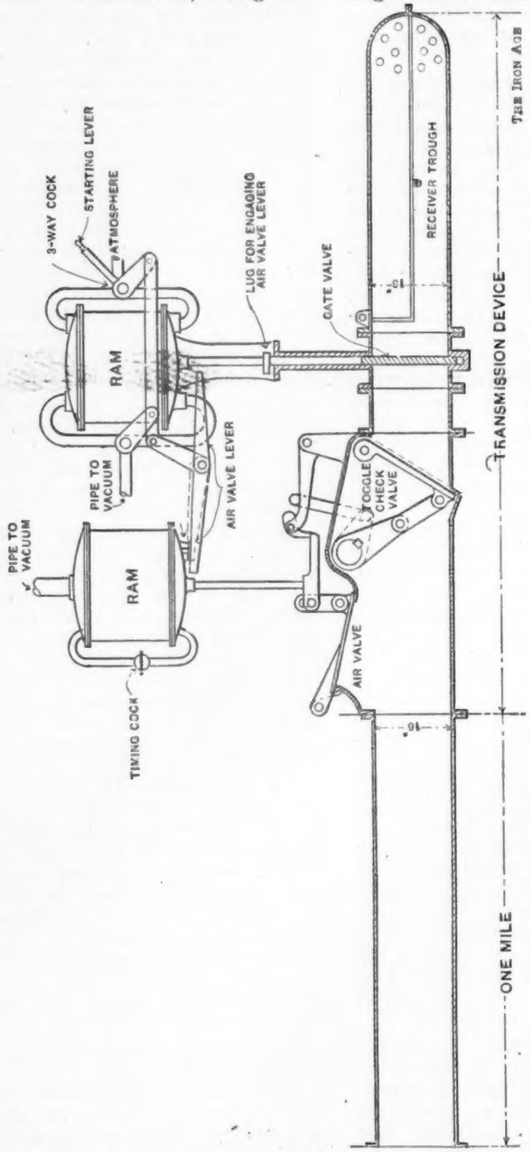
The conditions before depression of the starting lever are as follows: The three-way cocks to right and to left of the ram chamber above the gate valve are in the position shown, such that atmospheric pressure from the right is admitted to the top of the ram chamber, while the lower portion of the cylinder is in connection with the vacuum system by means of the pipe shown leading off toward the left. These three-way cocks are so connected as to operate simultaneously to reverse the connections, admitting atmosphere below and opening the top to connection with the vacuum. When the operator depresses the starting lever he reverses the connections, as stated, so that the ram, which ordinarily is down, is forced upward, opening the gate valve. The connecting rod joining the three-way cocks is extended toward the left to connect with one arm of a bell crank lever whose other arm is thrown downward when the starting lever is depressed. When thus thrown downward this arm breaks the toggle joint, which has meantime held the check valve in the transmission tube closed against the admission of air. With the toggle joint broken the check valve is immediately opened by the carrier, impelled by the air entering through the perforations in the end of the receiver trough. When the gate valve reaches an open position a lug upon its stem strikes the air valve lever above, opening the air valve at the bottom of the left hand ram chamber. As indicated, this ram chamber is connected by a pipe from its top to the vacuum system. Admission of air below the ram, therefore, acts to drive the latter to the top of the chamber. The rise of the ram opens the air valve in the transmission line so that the entrance of atmospheric pressure may drive the carrier through the tube to the relay device.

After the carrier has been thus started upon its way, the operation, of course, being practically instantaneous, the attendant raises the starting lever to its normal position, as shown in the engraving. The atmospheric pressure thus admitted above the ram forces it downward, closing the gate valve and releasing the air valve lever. The air valve then closes automatically and prevents the entrance of more air underneath the left hand ram. Connecting the top and bottom of this ram chamber is a pipe, in which is a timing cock, so adjusted that the establishment of equilibrium above and below the ram by the passage of air from below will be accomplished as soon as the carrier has reached the relay at the end of the first section of the transmission line. When this equilibrium is established the ram descends by its own weight and by the suction produced by the rush of air by the valve below. When this valve is seated the entrance of more air is prevented and the closing of the check valve at the relay device cuts this first section of the system out of service, so that the air pump may proceed to rarefy the interior to place it again in normal condition.

Considering now the relay device, we find that at the right hand end is the suction connection between the transmission tube and the vacuum pipe below. This suction pipe forms the only connection between the transmission tube and the vacuum pipe for the first section of the system. Through this suction and into the vacuum pipe has passed the air within the first section, so as to maintain the partial vacuum in front of the carrier as it is driven through the tube by the atmospheric pressure behind. As the carrier passes this suction connection the check valve immediately above it is opened and then at once falls, so that when the air valve and the toggle check valve at the transmission end have closed the air pumps will restore the partial vacuum in this section. The relay device is practically a repetition of the apparatus connected with the left hand ram at the transmission end and performs essentially the same operation, passing the carrier on to the terminal device or to the next relay section, as the case may be. By a similar timing feature the ram of the relay device closes the air admission valve when, or soon after, the carrier has reached the terminal device or the next relay.

The terminal device requires little description. The carrier strikes and opens a check valve, which closes immediately after its passage, sealing the transmission tube against further entrance of outer air. The terminal device includes at its extreme end an air cushion chamber fitted also with a dash plunger, the space behind

which is in communication with the outer air by means of a vent cock, which may be set as required. The carrier, brought to rest in the air cushion chamber, will slide back, or may be drawn back for removal upward through the opening above the table top, this opening being made of a suitable length to allow passage of the largest carrier used.



THE DINSPEL-STOETZEL VACUUM SYSTEM OF PNEUMATIC TRANSMISSION.

It will be seen, therefore, that at the transmission end and at each of the relay points air for driving the carriage is ad-

mitted only for a sufficient length of time to carry the cartridge through one section and into the next. Thus is eliminated the necessity, common in other systems, for pushing a continuous column of air through a long mileage of tubes. It is stated by the designers of this new system that in any of the old ones it has not been found practicable thus far to economically convey matter continuously a greater distance than about 2 or 3 miles, owing to the tremendous frictional resistance of a column of air of that length. In consequence it is held that, under the best of conditions, the dispatch of mail matter by means of any of the pressure systems is attended with greater expense than would be involved in sending by wagon or other method, the pneumatic transmission being used in spite of this great expense only because of its greater speed. The promoters of the Dinspel-Stoetzel vacuum system state that it is possible to send a carrier weighing as much as 500 pounds through a tube 16 inches in diameter at the rate of about 2 miles per minute, with a vacuum of only 6 inches of mercury, and that it would be entirely practicable to send matter from New York to Chicago by this system, timing devices being placed at intervals of from 2 to 3 miles, and relay pumping stations being located at points of economic advantage at longer intervals along the line.

It is of interest to note that the city of St. Louis has granted a franchise for the installation of this system between the Union Station in the centre of the city and the Transportation Building on the grounds of the Louisiana Purchase Exposition—a distance of 4½ miles. In this installation a series of large and small service lines for sending and receiving express and mail matter will be served by a vacuum pipe of corresponding size. It is proposed to carry freight and express packages from the city to the fair grounds at a speed of at least a mile per minute. This enterprise is not in connection with the United States Government, but will be devoted to the transmission of miscellaneous freight backward and forward between the fair grounds and the city. The distance will be divided into relay sections of suitable length. It is estimated that the installation will cost somewhat more than $100,000, and the company agree, by the terms of their franchise, to give the city of St. Louis 5 per cent. of the gross receipts.

The introduction of the system in this country is being made by the Universal Pneumatic Transmission Company, of which Joseph J. Stoetzel, one of the patentees of the system, is president. Other officers are: F. J. Rugly, vice-president; G. E. Burns, second vice-president; A. J. Williams, secretary; Siegfried Melohn, treasurer. Meysenburg & Peebles, Boston, are fiscal agents. The general offices are at 231 Canal street, Chicago.—*Iron Age.*

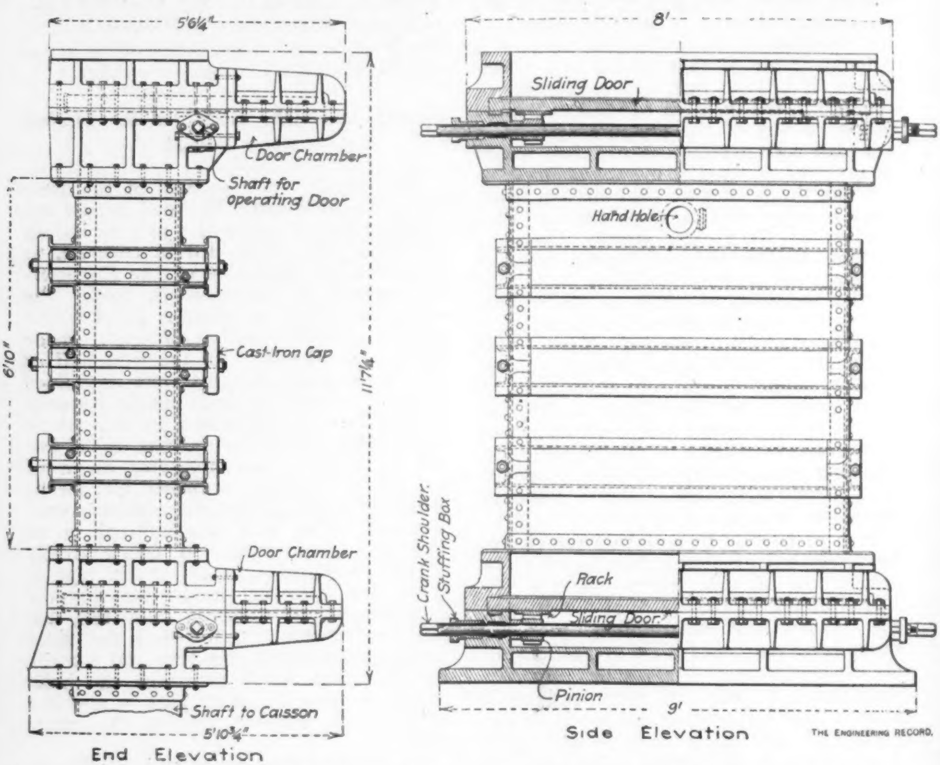
Special Pneumatic Lock for the Harlem River Tunnel.

The double track subway of the New York Rapid Transit Railroad across the Harlem river consists of a pair of 15-foot cast-iron tubes embedded in concrete, as described and illustrated in *The Engineering Record* of September, 5, 1903. The cast-iron shell is in sections about 6 feet square, bolted together through inside flanges on all sides. In the west half of the tunnel these sections were assembled under pneumatic pressure inside a special timber caisson, illustrated in the article mentioned. The large sections of the lining were heavy and somewhat awkward to handle through ordinary air locks; therefore a special material lock was constructed. This lock was unusual in its dimensions, of wide and comparatively narrow proportions, for the special type of doors and operating mechanism, for the combination of cast-iron and steel, for the reinforcement of the long flat sides against unbalanced pressures and for the movable disc which permitted the hook of the hoisting tackle to pass in and out of the lock without opening the upper door.

The general appearance and dimensions of the lock are shown in the side and end elevations herewith. It consists essentially of three chambers. The centre chamber is of steel plates riveted to inside vertical corner angles and is reinforced by outside yokes. The top and bottom chambers are similar and are each made of four castings flange-bolted together and fitted with horizontally sliding doors operated by racks and pinions commanded by exterior hand cranks.

These outside yokes are made with pairs of 6-inch channels 8 inches apart at the back, riveted horizontally across the wide

sides of the chamber. Their ends project sufficiently to engage the flanges of single 8-inch channels riveted across the narrow sides of the chamber. Cast-iron bearing plates are seated on the ends of the 6-inch channels and receive tension rods which, together with those at right angles to them through the ends of the 12-inch channels, are screwed up to considerable horizontal flanges of the joints between the top and bottom castings of each chamber are planed to receive the solid rectangular cast-iron doors 3 inches thick, which slide on bearing strips set in the lower castings. The doors are planed to a close fit, so that there is little or no leakage around them, and to the lower side of each there is attached a rack extending from



DETAILS OF PNEUMATIC LOCK USED IN CONSTRUCTING THE HARLEM RIVER TUNNEL OF THE NEW YORK RAPID TRANSIT RAILROAD.

initial tension, thus providing very stiff and solid reinforcements in both directions.

The upper and lower chambers have top and bottom pieces which cover the central chamber and are separated by horizontal joints. These pieces are extended on one side beyond the central chamber by the addition of end sections which receive the sliding doors when open. The end to end. These racks engage pinions on horizontal shafts passing through stuffing boxes in the lower castings of each chamber. The shaft projects sufficiently outside of the chamber to receive the movable cranks at both ends.

In the centre of the upper door there is a hole 7 inches in diameter bored to fit a flanged cast-iron plug made in two equal parts, with a diametrical joint hav-

ing rubber gaskets on both sides. The plug is bored through the centre to receive a brass bushing tightly fitted to the hoist rope. Each half of the plug is provided with two carefully fitted hook bolts having lever handles on the upper side. These bolts serve as buttons, lock the plug in position and are easily opened by a quick twist so as to allow the halves of the plug to be separated and removed so as to permit the hook to be lowered through the lock door without opening the latter.

The lock was designed and manufactured by the Cockburn Barrow and Machine Company, Jersey City, Mr. William McIlvrid, general manager, for Messrs. McMullen & McBean, contractors for the Harlem crossing.—*The Engineering Record.*

A New System of Air Brakes with Electric Control.

Messrs. Siemens & Halske, of Berlin, have developed a system of pneumatic brakes with electric control which, they claim, is superior in some respects to the compressed air brakes now in general use. A series of trials were made with the sanction of the German Government, after which this system was operated on several railway lines in Germany. It was claimed that the old methods were rather slow of operation, causing the last cars in the train to strike violently against those that were already braked. This new device is claimed to operate simultaneously from any point in the train the brakes of all the cars. This system is described in *The Practical Engineer* (English) as follows:

"Between the principal conduit and the brake cylinders are interposed valves, kept closed by the pressure of the air, but which can be opened under the action of electro-magnets, which cause the braking to take place. The electric current is turned into these magnets by the working of a commutator thrown into gear with the brake cock by the operator. Analogous cocks are provided on the cars for urgent stoppings. In case of lowering of the pressure of the conduits, the brakes are at once put in action. A complementary contrivance effects the braking, in case of rupture, of the electric circuit or short circuit.

"The commutator is arranged on the braking valve in such a way that, except the handle, the valve is not modified, and the valve and connector can be actuated by the one handle. To actuate the brake electrically, the lowered handle is first put in the closing position, and then continues to be turned. An electric contact is thus established; the current traverses the valve, and induces the simultaneous action of all brakes. If then the handle is relaxed, it starts back under the influence of a spring in tension, which cuts the current.

"The electric distribution valves are fixed to the frames of the cars and the tender. The pressure of the conduit bears upon the body of the valve, and keeps it closed, an electro-magnet serving, on the contrary, to open it as soon as it is traversed by the current. A ricochet valve prevents the compressed air from returning from the cylinder into the principal conduit. The remianing magnetism of the magnets is nullified by means of a spring.

"Electric bipolar couplings serve to connect the cables between the wagons and between the tender and the vehicle which follows it. The couplings contain two identical halves between them. The junction is secured by means of languets, and by the arrangement of the contacts. A caoutchouc ring prevents the penetration of water into the couplings, penetration which would, however, not impede the working, but which would, in course of time, act on the contacts. A spring device prevents the couplings from disengaging accidentally.

"The connection of the cables between the locomotive and the tender is effected by means of a tetrapolar coupling, which is distinguished from the bipolar couplings only by the adjunction of two hinged contacts, which connect the source of the current (usually accumulators and dry piles) placed on the tender with the distribution table.

"False couplings preserve the uncoupled halves of the couplings from water and dust, and give an issue to the cables. They are fixed to the principal walls of the cars.

"The commutator of the safety brake is shaped like a closed cylinder, in which works a rod connected with the lever of the cock of the safety brake. On the rod, which is constantly on the ground, are contrived spring rubbers, which bear upon an isolated ring as soon as the rod is

slightly pulled in consequence of the opening of the cock of the safety brake. A contact connects the ring with the cable.

"A ricochet valve is interposed between the principal pneumatic conduit and the reservoir of the brake valve in such a way that the air can penetrate into the conduit, but cannot return backwards. The manometer marking the pressure in the reservoir of the valve may thus serve to measure the pressure in the principal conduit.

"The junction valve is attached to an iron projection fitted at the principal wall. The junction with the principal conduit and with the electric conductors is made by means of special couplings. It contains a second valve, provided between the principal conduit and the outer air. It is kept closed by an electro-magnet and with continuous current. In case of interruption of the current, it opens automatically by the pneumatic pressure of the conduit."

A record of its operation is given by the same publication, as follows:

"The first trials made with the system took place on the military line, Berlin to Zuterborg (70½ kw.). The device was, however, not completed. The installation, nevertheless, worked perfectly in the daily service and to the satisfaction of the staff.

"The complete system is in operation on four trains running regularly between Berlin and Stralsund. These trains are composed of cars of different kinds, one equipped with Westinghouse brakes and the other with friction brakes.

"The new system works there in a very satisfactory manner. According to the evidence of the staff, this method of operating the braking excludes any chance of failure of the brakes, as the latter work instantaneously as soon as the braking power descends below certain limits. The consumption of current is exceedingly small on the average, ½ ampere-hour per day. The battery, having a capacity of 9 ampere-hours, can thus work 18 days without being recharged. This small consumption of current permits the employment of a battery of dry cells, which is very important on lines where accumulators cannot be recharged.

"When trials were made on trains of great length (two locomotives and 110 axles) one of the cars was provided with Kapteyn registers. The results were sufficiently favorable to continue the experiments. The declivity was often 1 in 200. No shock was ever felt. Numerous trials were made, especially on goods train and in putting a great number of cars out of circuit, and gave absolute satisfactory results."

Notes.

The Taisey Pneumatic Service Company is reported to be preparing to move its plant from Indianapolis to Buffalo.

The Pneumatic Signal Company announces that it will not remove its plant to Buffalo, but will continue at its present site in Rochester, N. Y.

The United States Pneumatic Power Company, of South Berwick, Me., has been incorporated with a capital of $250,000. Mr. C. M. Hobbs is the incorporator.

A hotel at Mobile, Ala., has installed a compressed air cleaning plant of its own. It will be used to do all the sweeping and cleaning of the rooms, as well as cleaning carpets, hangings and furniture.

Peter Nissen's unique craft, which he calls a pneumatic ball, was given a trial on Lake Michigan. It is a huge balloon-like device filled with compressed air which the wind was supposed to roll along. The ball simply floated across the water and refused to roll.

The Rand Drill Company, of No. 128 Broadway, New York, has just issued a pamphlet entitled "Air and Gas Compressors." This miniature compressor catalogue illustrates and describes briefly some of the standard types of air and gas compressors made by that company. A copy can be obtained upon application.

Among the recent English patents is one for an improvement to an air compressor secured by W. Reavell and Reavell & Co., Ltd., of Ipswich. According to this invention the crank pin is lengthened and the cylinders are arranged in two planes parallel to each other but sufficiently far apart to give the required width to the connecting rod ends.

One of the latest novelties in which compressed air figures is a pneumatic boat built on the principle of a pneumatic tire. These are built of two kinds, either of rubber cloth inflated with air and divided into two compartments, or of a series of inflated tubes coiled lengthwise. It is said a boat large enough to carry six persons may be carried in a valise or trunk.

A steam operated air drill may be used underground, but the use of the steam driven drill is mostly confined to quarry work, and is rarely seen there now. Air is superior in every way, and the loss is efficiency in driving the compressor by a steam engine is more than offset by the facility with which the drill can be handled. to say nothing of the comfort and health of the men.—*El Paso* (*Tex.*) *Times.*

A decision has been reached in the suit of the Chicago Pneumatic Tool Company versus The Philadelphia Pneumatic Tool Company. On April 30, 1904. Judge Hazel, of the United States Circuit Court, filed an opinion sustaining the Chicago company's Moffett drill patent and holding the Philadelphia-Keller drills to be infringements, and directing an accounting of profits and damages, and enjoining the further manufacture, sale or use of such drills.

The Hamburg Senate proposes to arrange for the construction of a tunnel under the Elbe. The Clyde tunnel at Glasgow has been taken as a model for this plan, and it is intended that the tunnel shall run from the St. Pauli landing place on the north bank of the river to the Steinwarder bathing establishment on the southern bank. It is proposed that two tunnels of 4.8 metres internal diameter shall run beneath the river at the two points named. and passengers be conveyed by means of a lift at each extremity of the tunnel. The time of building is estimated at from two to three years.—*Mechanical World.*

The fact that the British Admiralty was compelled to call on a private concern to assist in raising submarine hulk sunk by collision off Portsmouth, has called considerable attention to this class of engineering work. The Liverpool (Eng.) Salvage Association has two large steamers for this work which are very well equipped with compressed air appliances. On each ship there is a compressor with a capacity of 250 cubic feet per minute which supplied air at 100 pounds pressure, which divers can use at 12 to 14 fathoms depth for operating pneumatic riveters, drills, caulkers, or chisels to effect temporary repairs in wood or metal.

The electric railway system in Charleroi, Belgium, owned by the Société Nationale des Chemins de fer Vicinaux, has recently been equipped with the Westinghouse storage air brake system. The line is about 16 miles in length and is equipped with 39 motor cars and the same number of trail cars. The power station is about the centre of the system and the air compressors are located at that point. They are two in number and driven by a 17 horse-power motor. The company has one auxiliary compressing station, which is also equipped with two electric compressors. The motor cars are fitted with two compressed air reservoirs, with a total capacity of 750 litres. The trail cars are equipped with brake cylinders and rigging, but not with reservoirs.—*Street Railway Journal.*

Considerable attention has been drawn in England to the disease known as miner's phthisis on account of an inquiry that was made into the death of a miner who died near Truro, Cornwall. Dr. Haldane, of Oxford, made an extensive report on the subject in which he declared that all miners appeared to be exposed to this disease, but that it was most severe in the case of rock drill miners. Dr. Haldane recommended the use of water jets to keep down the dust, advising that they should be made compulsory by law. The coroner's jury, in rendering its verdict, recommended, "that in view of the large number of miners who have recently died in this district from the effects of dust inhaled in rock drilling and other underground work, particularly in the Transvaal and also in Cornwall, we consider that special legislation for the purpose of dealing with this very grave source of danger to health is urgently called for." This subject has since been brought to the attention of Parliament, but so far no action has been taken.

Two passages in the presidential address of Sir George Farrar to the Chamber of Mines should dispel the prudish misgivings of the Home opposition to Transvaal mine owners. Therein he showed that almost a half-million had been expended in recruiting labor for the mines, and that rock-drilling appliances, including compressor plants, while effecting a saving equivalent to the labor of 37 000 natives, represented capital expenditure amounting to £1,250,000. These statements, taken together, complete a chain of circumstantial testimony which impartial electors, solicitous about the future of the white miner, will accept. No industrial centre, no voluntary association, has ever been forced to such extremes in the struggle for progression. Without the rock drill the Rand would have been as hopeless since the Peace compact as it now is hopeful. More of this mechanism is in use here than in any other gold-producing country, and orders in process of execution indicate that the demand is increasing.—*South African Mines (Johannesburg).*

The Lackawanna has designed an air compressor car which can be placed to one side of the main track without the necessity of building a spur track near the bridge or structure which is being built or repaired. Under each corner of the car is hinged a screw-jack. These jacks reach within 8 or 10 inches of the ground, and in order to raise the car, blocking is placed beneath the jacks. When it is desired to remove the car from the main track, the car is first raised a few inches by means of the jacks and blocks. The centre pins of the trucks have nuts on their lower ends so that the trucks raise with the car. As soon as the truck wheels are clear of the rails, each truck is turned at right angles to the main track. The car is then lowered on short sections of rails and is pushed off to one side to the desired position. This entire operation requires but 20 minutes. All blocking and rail sections are carried on the car. The car is the standard box type, 40 feet long, and reinforced to withstand the severe strains due to jacking. The car is equipped with a 22 horsepower Otto gasoline engine which is connected to a No. 11 Rand air compressor. The car is also fitted with gasoline, water and air reservoirs. A complete complement of air tools, pipes, fittings, etc., used on steel construction work is carried. We are indebted to W. B. Hixson, Superintendent of Bridges and Buildings, for the above details.—*Railroad Gazette.*

A project to connect England and France with a tunnel under the English Channel has been revived and the subject is receiving considerable attention at the hands of the English press. Such an enterprise was started 50 years ago and some work was done. In the eighties further efforts were made and an excavation made from both ends. The actual entrance to the tunnel at the English side was 1½ miles inland and the bore was planned to slope gradually downwards some 6½ miles out, whence it would rise to the margin again at the other side. Before the work was stopped a heading of 1½ miles had been driven in the gray chalk. A compressed air boring machine was used, the teeth of which cut the soft chalk into fragments and loaded it automatically into cars. The tunnel was 7 feet in diameter. On the French side a similar tunnel 2,200 yards long was bored out from Sangatte, near Calais to meet the English works. With the implements of that day the excavation was carried on at the rate of 100 yards a week. With the modern tunnel methods it is generally believed that the heading could be driven with considerable speed and with every chance of success. Tunneling through the chalk does not offer any great obstacle while the shield method could be utilized if the heading ran into a strata of mud. The tunnel was given up as it was deemed dangerous to connect England with any foreign country in such a way that advantage might be taken of it in case of war.

A series of rock drill tests is described in a paper read before the Mechanical Engineers' Association, an abstract of which appears in the *Engineering and Mining Journal* of May 12. The tests were made in South Africa. Vertical holes were drilled in granite blocks 2 feet thick, a careful record being kept of the air consumption of each kind of drill. The lowest average air consumption, for a range of pressure, from 35 to 85 pounds per square inch, was 10.52 cubic feet of free air per cubic inch of rock drilled, for a 1⅜-inch Slugger drill. One drill

consumed as high as 21.52 cubic feet of air per cubic inch drilled. As given in the abstract, the records do not state the length of each test, nor the diameter of the bits, nor the depth of each hole—all being factors of the greatest importance. The wages of the drill crew are a more important item than the cost of power, hence the speed of drilling should have been stated. There are not to be found in print any reliable data as to the effect of diameter of hole upon speed of drilling with power drills, hence the cubic inch of rock drilled means little or nothing. Finally a power drill that is very effective with a drill only 2 feet long may prove quite ineffective when the weight of steel to be lifted is several times greater. Careful tests of drill efficiencies are much to be desired, but, unless they show more than these tests do. they add little to our stock of knowledge.—*Engineering News.*

Undoubtedly the rock-drill is a factor of vast economic importance to Rand mining. From the experiments that have been conducted, says *South African Mines,* it would seem that too much attention has been paid to the cost of maintenance, and in consequence the consumption of air has been somewhat lost sight of. We understand that the findings of the "rock-drill" commission are to the effect that a policy of false economy has been pursued in consequence of this, and that in the future the neglected factor will be held in very much higher esteem than in the past. While the adoption of a machine whose cost of up-keep is minimized by its construction is a decision that will meet with the approval of all superintending engineers, no sound mechanical institution can indorse this policy if the machine's consumption from the compressor more than absorbs this saving. In the future it will be found advisable to allocate certain machines to certain mines, and to abolish the old method of "mixing the breed" by employing, say, 10 Sluggers, 15 Ingersolls, 10 Leyners and 20 Climaxes, for a mine requiring 55 drills. It will be found more advantageous for one mine to approve of one machine for its use, and one machine only, be it Climax or Ingersoll, Leyner or Slugger, or any other make, for the advantages in the fitting shops will soon prove themselves. Since the declaration of peace a fresh element has entered into the arena of rock-drill development. The gravity of the disease known as "miners' phthisis" has been realized for many years, but until the resumption of crushing no very active steps were taken to minimize the dust scourge. The action of the Chamber of Mines, the findings of the Phthisis Commission, and the discussions of technical societies have all tended to bring the matter into prominence, and the drill of the future must have the after-war qualifications of a dust allayer in some form.

For some time past important experiments have been carried on in Manchester to ascertain the possibility of the industrial production of liquid air and the separation of its component parts, oxygen and nitrogen, by fractional distillation. A complete plant has been erected at Messrs. Galloway's Ardwick works, where exhaustive tests have been made daily during the last month. Some of the later experiments made by M. Meyrneis, under the control of Professor Dixon, of the Manchester University, have demonstrated that the plant is capable of working on a commercial scale. Its many industrial applications for oxidizing purposes, especially in bleaching, as well as for lighting and obtaining the high temperatures required in metallurgical works, and its important possibilities in the solution of the sewage problem, give the invention an interest for the community at large. The existing plant at Messrs. Galloway's works produces about 200 cubic metres (706 cubic feet) of industrial oxygen per hour, obtained from liquid air, which is made at the very low pressure of about four atmospheres. It is here possible to see liquid air flowing from the coils into the apparatus, and its regular production is about 700 litres (154 gallons) per hour. Until now the production of liquid air required the very high pressure of about 200 atmospheres (about 2,844 pounds to the square inch). The progress indicated by the reduction of that pressure to one of four atmospheres means briefly the transfer of liquid air from the laboratory to the workshop. But this manufacture, so attractive in itself, opens out at the same time a wide field for scientific investigation by reason of the low temperature of the liquid air. This temperature is about 195 degrees Cen., or about 383 degrees below zero on

the Fahrenheit scale. It has already been ascertained that at such temperatures there exists an emission of cold rays which penetrate solid bodies in the same way as the X rays of Rontgen.—*Practical Engineer (Eng.)*.

An interesting paper on coal cutting machinery has been presented to the Royal Society of Engineers of England by A. S. E. Ackermann, who has investigated the development of coal cutting machinery in America and was one of the witnesses examined by the Royal Commission on Coal Supplies. Mr. Ackermann explained that the chief types of machines in use in Great Britain are the long wall disc machine and the long wall bar machine. The average net saving on the cost of coal-getting in England as the result of the use of machines is 6d. per ton, and the average increase of output per man employed has amounted to 65 per cent. In addition to those advantages, coal cut by machinery contains 12 per cent. more round coal. The cost of a complete plant is about £1,000 per machine. The individual electric long wall machines cost about £400 each, the pneumatic ones £250, and the pneumatic percussive £75 to £100 each. American experience is that on the average 10d. per ton is saved in the cost of getting by the use of machines. The output per machine per year in America is 11,480 tons, and in England 8,620 tons.

According to Mr. Ackermann, the favorite type of machine in England is the long wall disc machine, 82 per cent. of all the machines being of that type. In America the punching machine is the favorite, 59 per cent. of the machines being of that type. In 1902 there were 483 machines in use in England, and 5,418 in America. In England in the same year 1.83 per cent. of coal was cut by machines, and in America 23.5 per cent., or, if in the latter case only bituminuous coal were considered, then 26.75 per cent. was cut by machines.

The striking fact was mentioned by Mr. Ackermann that from 1896 to 1902 the output per year per person employed had decreased in England from 291 tons to 282 tons, while in America it had increased from 504 tons to 628 tons. The author showed that the States of Pennsylvania, Illinois, West Virginia, and Ohio, which cut large percentages of their coal by machines, had, on the average, a lower death rate per million tons of coal raised than those States which had a smaller output and cut a smaller percentage by machines.

To increase the flow of artesian and other wells in the San Joaquin valley, an air-lift system of pumping by compressed air is being employed. The system is quite simple. The discharge pipe of the compressed air plant is carried to the bottom of the well and the release of the air at that point creates a vacuum in the water-bearing stratum, which increases the flow. At the Wakena colony's land in Tulare County a plant of this kind has just been put in operation and a previously flowing well is now yielding 27,154 gallons of water per minute, or five times the natural flow. It is now proposed to apply the system to a well in the same neighborhood which has pierced the water belt, but which is not flowing, and it is expected that equally good results will be obtained. The second well is to be operated by the engine furnishing power to the compressed air plant, which has produced such satisfactory results in the flowing well.

Around the bed of Tulare Lake are a number of wells yielding water, with natural gas in solution. Some of these wells yield enough water to irrigate 160 acres of land. A number of them, which are only two inches in diameter and not over 200 feet in depth, yield 1,500 cubic feet of natural gas daily. Larger wells sometimes give over 10,000 cubic feet per day. These wells are found throughout a territory exceeding 800 square miles. Many of them have been flowing for over ten years without any diminution in the yield of either water or gas, the gas being used for domestic and other purposes and the water for irrigating the land. The water containing gas in solution in these wells is being permanently replenished by meteoric water and the decomposition of petroleum in the known oil fields of Kern, Coalinga, Sunset and McKittrick, and possibly other undeveloped oil fields in the neighborhood. The presumption is, therefore, strong that the supply of both gas and water is inexhaustible.

It has been found by experience, however, that a compressed air lift will not increase the flow of available gas while increasing the flow of water, because the

mixture of the air with the gas degrades the latter. Ex-State Mineralogist A. S. Cooper has, however, invented a method of employing compressed gas instead of air, which performs all the functions of the air lift, obviously without degrading the gas, thus increasing the outflow of gas as well as that of water. The system has been put to practical test with success. It is reasonably assumed, of course, that by the application of this system the flow of a well producing water and gas will be so increased that the volume of the latter will furnish enough natural fuel to operate the whole plant. If the system fulfills this promise it will add materially to the natural resources of a large area of territory in the State where both elements are in evidence.—*San Francisco (Cal.) Chronicle.*

In the early part of 1897 an effort was made to find out the actual costs of upkeep of a machine placed in the hands of competent miners, and subject to special supervision. The machine was specially prepared before being sent underground, the cylinder being very carefully bored out to insure a glassy-like surface inside and to make it perfectly parallel. A special piston, made from high carbon steel, was made and ground into the cylinder, great care being taken to insure the tightest possible working fit; all of the piston was made dead hard, except the chuck-rod and chuck, a special arrangement being provided on one of the lathes to grind the piston down to the required size. A special valve of tool steel was formed and fitted to the valve chest, after it had been carefully bored out, the same precautions being taken to insure a good tight fit, as in the case of the piston and cylinder. The remaining portions of the machine received very careful attention, and everything possible was done to insure the machine being in perfect order.

The machine ran fourteen months, double shift, in the hands of the same men, with the exception of four occasions when it was in the shops for extensive overhaul of cradle and front-head; on each occasion it was laid aside twenty-four hours. During the entire period under observation there were four new valves fitted, nine chuck-bolts, eleven chuck-bushes, six rotating nuts, twelve sets ratchet pawls and springs, three feed-screws, three feed-nuts, six sets front-head bushings; no work was done on the piston proper. So pleased were the men with the performance of the machines that they preferred to lie off during the periods referred to rather than handle another machine. The costs might have been followed up for a longer period, but unfortunately the machine got injured due to blasting; on being brought to the surface the wear between the cylinder and piston amounted to 16-100ths of an inch, as measured by the micrometer. The following were the costs:

	£	s.	d.
Machine repairs at start......	£15	0	0
Eleven chuck bushes, at 12s...	6	12	0
Nine chuck bolts, at 4s. 9d....	2	2	9
Four new piston valves, including reaming chest.......	4	15	0
Six rotating nuts, at 12s. 6d...	3	18	0
Twelve sets ratchet pawls, at 9s.	5	8	0
Three feed screws, at 21s.....	3	3	0
Three feed nuts, at 21s........	3	3	0
Six sets front head bushings and leathers, at 20s.........	6	0	0
Labor	26	0	0
Allowance for mechanical power	17	10	0
Supervision, office charges, etc.	14	0	0
	£107	11	9

Equal to £7 13s. 8d. per month.

The approximate footage drilled was 13,104 feet.—*South African Mines.*

The following letter was published among the communications in the *Engineering News* for June 2d:

"Sir—Having charge of a large air plant, I noted with interest a recent article in your editorial columns in regard to air supply for forges from a compressed-air plant of high pressure, and although I am without data of any value, I do not accept as proven that a jet of compressed air impinging on the back of the blades of a fan, will deliver a large volume of air at a suitable pressure than if used in what you term an ejector.

"If I understand your term, an ejector is a jet of high pressure air through an opening of considerably greater area, by which means a large volume of atmospheric air is induced, mixed and discharged with, the jet. I have looked in vain for any reliable data regarding volume and pressure under these conditions, but have had in use for nearly a year a device of this kind; that, with

less than 7 cubic feet of air (by table in Hiscox's "Compressed Air") at 100 pounds pressure, operates rivet forges much more satisfactorily than was previously done with a direct blast of compressed air from which the atmosphere was excluded. I have had another device (maker unknown) which admitted compressed air through an annular opening around a tube about 3/8 inch diameter. This gave a pretty high pressure but was deficient in volume for the required purpose. The ejector blowers which I now use have a nozzle opening made with a No. 52 twist drill, flared slightly at the outer end and discharging into a hollow frustum with an opening 1¼ inches in diameter at the small end: the end of the nozzle being about 3 inches back from the opening and in line with the centre.

"I have found that a straight tube extending 3 or 4 inches from, and of the same diameter as, the small end of the frustum, increases the efficiency, but have not been able to determine to what extent.

"I have recently by another device applied to heavy forges, raised to a welding heat a bar of 4-inch iron in less than 18 minutes, with an estimated expenditure of 38 feet of air per minute at 100 pounds (by table as before). I have not applied such a device behind the blades of a fan, though if that should be done, and the fan then takes in air, it would certainly go far toward proving the efficacy of an air jet applied in that way; but the result of such few experiments as I have been able to make, inclines me to the belief that more can be obtained from compressed air by induction than by actuating machinery with it for the purpose under discussion.

"I have found that very slight differences of size and form make wide differences in the results, and estimating consumption from tables and formulae is quite another matter from measuring actual volumes. I would like to know if any of your correspondents have any reliable means of measuring air volumes at or near atmospheric pressure, at a reasonable cost.

"My experiments show that the induction of air is a wide and promising field for investigation, and I believe in the possibility of valuable devices for producing lower pressures by other means than reducing valves, in which the difference of pressure is a dead loss.

"Sand blasts, pneumatic painting machines, and other devices of that class ought to be operated in such a way as to return at least a portion of the surplus energy by inducing air at the required pressures, and may it not be possible that stored pneumatic power at higher pressures would yield greater efficiency if handled in the same manner.

"Yours respectfully,

"EDMUND HOXIE,

"78 Clinton Street, Everett, Mass.

"May 16, 1904."

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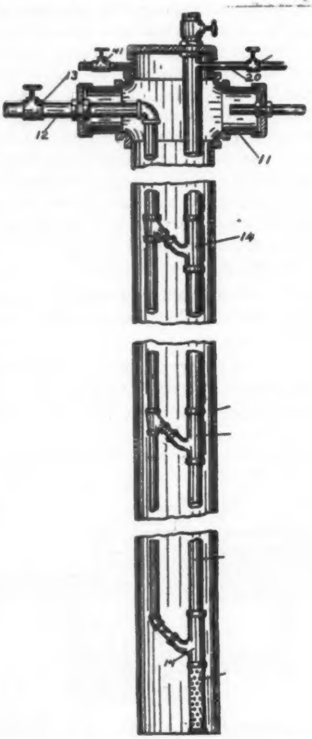
U.S. PATENTS GRANTED MAY, 1904.

Specially prepared for COMPRESSED AIR.

758,666. VALVE FOR PNEUMATIC MUSICAL INSTRUMENTS. Eugene De Kleist, North Tonawanda, N. Y. Filed July 6, 1903. Serial No. 164,310.

758,885. ARMOR FOR PNEUMATIC TIRES. Jonas W. Aylsworth, East Orange, N. J. Filed Sept. 13, 1902. Serial No. 123,203.

759.100. AIR OR GAS LIFT FOR FLUIDS. Walter B. Harris, Indianapolis, Ind. Filed July 6, 1903. Serial No. 164,359.

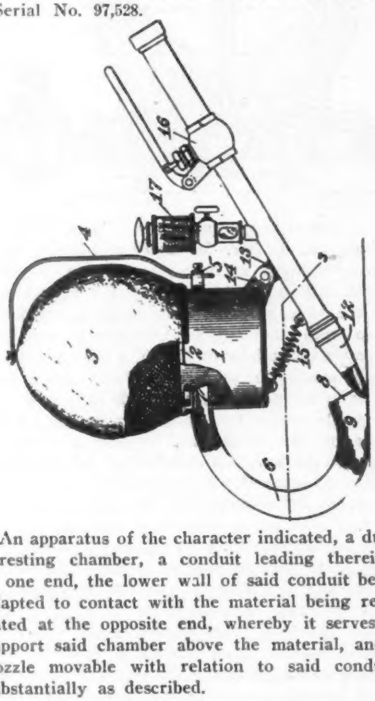


An air or gas lift for fluids including an air-tight casing, a delivery-tube extending downward in the casing with an inlet at its lower end, a pipe within the casing extending parallel with said delivery-tube, through which compressed air or gas may be conveyed, ejectors leading at intervals from said air or gas pipe to said delivery-tube, and means for introducing compressed air into the casing upon the body of fluid.

758,801. CONDENSING AIR-PUMP. Johannes Wilhelmi, Hamburg, Germany. Filed May 2, 1903. Serial No. 155,432.

A pump having a water-cylinder and an air-cylinder larger than the water-cylinder, pistons therein, a piston-rod connected to both pistons and means to produce an air-cushion at the termination of the downstroke, whereby the space between the large and small pistons in the air-cylinder causes by its vacuum action a compensation or balance of work between the two halves of a double stroke (up and down stroke), substantially as described.

759,141. PNEUMATIC RENOVATOR. John S. Thurman, St. Louis, Mo. Filed Mar. 10, 1902. Serial No. 97,528.

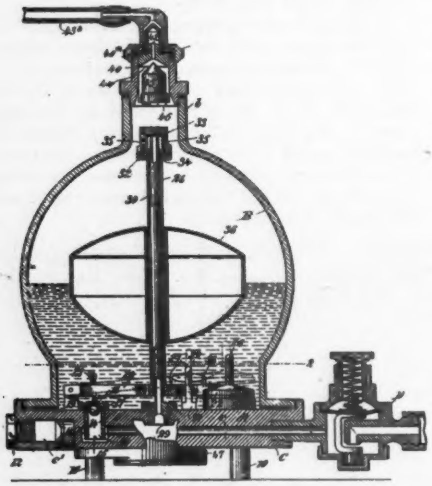


An apparatus of the character indicated, a dust-arresting chamber, a conduit leading thereinto at one end, the lower wall of said conduit being adapted to contact with the material being renovated at the opposite end, whereby it serves to support said chamber above the material, and a nozzle movable with relation to said conduit; substantially as described.

759,245. REGULATION OF PNEUMATIC-FAN SYSTEMS. John L. Creveling, New York, N. Y., assignor to Safety Car Heating & Lighting Company, a Corporation of New Jersey. Filed Oct. 3, 1901. Serial No. 77,372.

A pneumatic-fan system for railway-trains, the combination of a pneumatic fan carried by the train, a source of air-supply therefor and means controlled by the movement of the train for controlling the air-supply to the fan.

759,158. HYDRAULIC AIR-COMPRESSOR. William G. Cox, New York, N. Y. Filed Jan. 19, 1903. Serial No. 139,608.

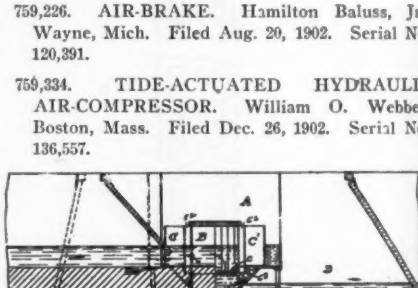


A hydraulic air-compressor, a body-section provided with an inlet for liquid and having an air-delivery valve at its upper portion, a tubular guide within the body-section for admitting air to the same, the said guide being in communication with the outside atmosphere and unobstructed throughout its length, a bonnet-valve normally closing the inner end of the tubular guide, a water-outlet for the said body-section, a lever-controlled valve for the said outlet, an auxiliary tube on the guide and forming a connection between the lever-controlled valve and the bonnet-valve, to move the lever-controlled valve on the final upward movement of the bonnet-valve, and a float mounted to slide upon the said auxiliary tube, which float upon its upward movement first raises the bonnet-valve to uncover the tubular guide, and next further raises the auxiliary tube.

A hydraulic air-compressor, a base, a dome upon the base, independent water inlets and outlets for the dome extending from the base, a plug or casing removably attached to the base and extending within the water-inlet, which casing or plug has an opening at the bottom and at the top, a ball-valve having free movement in the said plug or casing, means for preventing the ball-valve from leaving the plug or casing, a lever-arm pivoted upon the base within the dome, an adjusting-screw carried by the lever-arm, normally in engagement with the said ball-valve, a valve for the water-outlet opening of the dome carried by the lever-arm, a counterbalance-lever within the dome, having engagement with the under surface of the lever-arm, a tubular air-vent within the dome, extending through the base, being open at the top and at the bottom and being in communication with the outside atmosphere at the bottom, the said air-vent tube serving to admit air to the dome, and also serving when first uncovered to permit air to pass from the dome, for the purpose set forth, a bonnet-valve having apertures therein, mounted upon the upper end of the air-vent tube to normally close the same, an auxiliary tube mounted to slide on the air-vent tube and connected with the bonnet-valve and likewise with the said lever-arm, and a float mounted to slide freely upon the said auxiliary tube, which float in its lower position operates the said counterbalance-lever, and in its upper position first uncovers the upper end of the vent-tube and next raises the auxiliary tube a sufficient distance to carry the lever-arm upward and thus uncover the outlet-opennig in the base of the device, at the same time permitting the ball-valve controlling the inlet of the water to seat itself and prevent the inflow of water to the dome, the said adjusting-screw on the lever-arm acting when the outlet-valve is closed to force the ball-valve from its seat and permit the water to flow into the dome and an outlet for the compressed air leading from the dome for the purposes set forth.

759,226. AIR-BRAKE. Hamilton Baluss, Jr., Wayne, Mich. Filed Aug. 20, 1902. Serial No. 120,391.

759,334. TIDE-ACTUATED HYDRAULIC AIR-COMPRESSOR. William O. Webber, Boston, Mass. Filed Dec. 26, 1902. Serial No. 136,557.



A dike spanning the neck of a tidal basin, a hydraulic air-compressor consisting of a single shaft with a downflow-passage therein located in said dike, an inlet water passageway connecting said tidal basin with the ocean, and communicating with the head-tank of said hydraulic air-compressor, an outlet passageway connecting said tidal basin with the ocean and communicating with the upflow of said compressor, substantially as described.

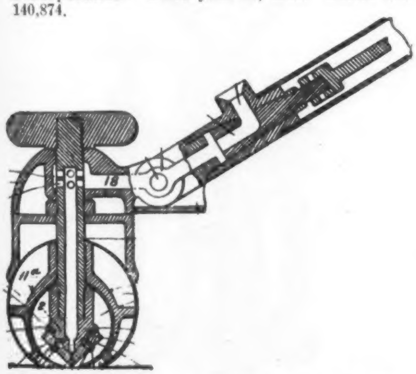
759,388. CAISSON. Daniel E. Moran, Mendham, N. J., assignor of two-thirds to Edwin S. Jarrett, New York, N. Y., and Franklin Remington, Greenwich, Conn. Filed May 24, 1902. Serial No. 108,835.

A pneumatic caisson having an internal portion of concrete extending throughout its height and in which is formed a shaft-opening, having a body formed of concrete extending solidly and in a single piece from such opening to the outer surface of the caisson, and having a working chamber of suitable dimensions to accommodate a workman, the roof of which is formed of masonry in a substantially uninterrupted mass with the body, whereby a substantially solid pier is formed of maximum weight and weight-supporting cross-section and whereby a transverse cleavage plane at the roof of the working chamber is avoided in the finished pier.

759,389. CAISSON. Daniel E. Moran, Mendham, N. J., assignor of two-thirds to Edwin S. Jarrett, New York, N. Y., and Franklin Remington, Greenwich, Conn. Original application filed May 24, 1902. Serial No. 108,835. Divided and this application filed June 30, 1903. Serial No. 163,748.

A pneumatic caisson having an internal vertically-extending portion of masonry and in which is a vertical shaft-opening and having a working chamber of suitable dimensions to accommodate a workman, the roof of said chamber being of masonry to form a substantially uninterrupted mass of masonry without a transverse division at the roof when the chamber is filled to form the finished pier.

759,452. PNEUMATIC CARPET-RENOVATOR. Augustus Lotz, San Francisco, Cal., assignor to Sanitary Compressed Air and Suction Dust Removing Co., San Francisco, Cal., a Corporation. Filed Jan. 28, 1903. Serial No. 140,874.



A combination in a pneumatic cleaning apparatus of a transversely-extended head having a centrally-located air-blast slit and air-passages connected therewith, a supplemental head inclosing the first-named head and having a plurality of suction-channels with their mouths located substantially parallel with and upon each side of the air-blast slit, plates upon opposite sides of the slit and movable toward and from each other to adjust the size of the slit and means connecting with said channels for the discharge of dust which is drawn into them.

759,659. STUFFING-BOX FOR GAS-COMPRESSORS. George Braungart, Jr., Chicago, Ill. Filed Sept. 12, 1903. Serial No. 172,894.

A device of the class described, the combination of a gas-compressing cylinder having a piston-rod extending through one end of same; a stuffing-box surrounding said piston-rod; a chamber in said stuffing-box, extending around said piston-rod and adapted to receive gaseous leakage from said cylinder; a second chamber in said stuffing-box, extending around said piston-rod, at the side of said first chamber which is away from the gas-compressing-cylinder, and adapted to contain a liquid under pressure; and means operated by the pressure of the gas in said first chamber and adapted to exert on the liquid in said second chamber a pressure greater than that of the gas in said first chamber, substantially as described.

760,680. PNEUMATIC CARRIER. Charles H. Burton, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Nov. 14, 1903. Serial No. 181,141.

759,687. RAILWAY-BRAKE APPARATUS. Charles J. Fisher, Murphysboro, Ill., assignor to Fisher Slack Adjuster and Railway Equipment Company, Murphysboro, Ill., a Corporation of Illinois. Filed Jan. 7, 1904. Serial No. 188,123.

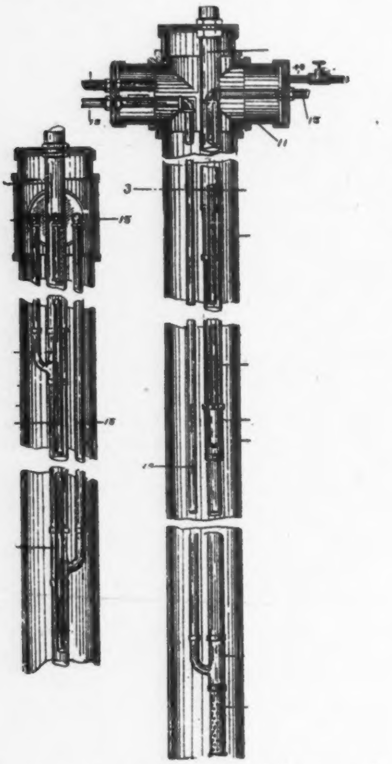
759,688. SANDER FOR LOCOMOTIVES. George W. Frazier, Alamogordo, N. Mex. Filed Sept. 3, 1903. Serial No. 171,776.

A combination with the sand-supply and delivery thereof, a suitable casing and a rotatable valve, means for working the said valve and means adapted for feeding air into it under pressure, the casing having an inlet and two outlet ports, the rotatable valve being constructed with opposite exterior recesses, and a vertical passage, enlarging from its lower end, adapted to provide open communication through the said inlet-port at any adjustment of the rotatable valve, substantially as described.

759,692. DUST-GUARD FOR AIR-HOSE COUPLINGS. Thomas Gaughan, Clinton, Iowa. Filed Aug. 19, 1903. Serial No. 170,005.

759,784. AUTOMATIC TRAIN-PIPE COUPLING FOR AIR-BRAKES. Richard J. Weken, Everett, Wash. Filed Jan. 28, 1904. Serial No. 191,044.

759,706. AIR OR GAS LIFT FOR FLUIDS. Walter B. Harris, Indianapolis, Ind. Filed July 6, 1903. Serial No. 164,360.



An air or gas lift for fluids including an air-tight casing, a single delivery-pipe within the casing, ejectors connected with and arranged in said pipe at intervals, a separate pipe leading to each ejector through which compressed air or gas may be introduced, and means for introducing compressed air or gas into said casing to press downward upon the body of fluid therein.

759,858. AIR-BRAKE MECHANISM. Guss A. Brooks, Covington, Ky. Filed June 15, 1903. Serial No. 161,425.

760,003. REGULATOR FOR ELASTIC-FLUID TURBINES. Tore G. E. Lindmark, Stockholm, Sweden. Filed June 27, 1902. Serial No. 113,530.

In combination with an elastic-fluid turbine-wheel, a device controlling the admission of live working fluid to the inlet of said wheel, and a device controlling the admission of live working fluid to the outlet of said wheel, substantially as described.

760,088. PNEUMATIC VIBRATOR. Henry Tonjes, Mount Vernon, N. Y., assignor, by mesne assignments, to the American Vibrator Company, a Corporation of Ohio. Filed Aug. 4, 1902. Serial No. 118,279.

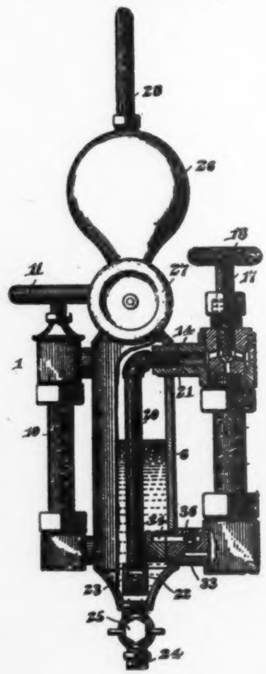
760,106. ELASTIC-FLUID TURBINE. Charles G. Curtis, New York, N. Y. Filed Aug. 1, 1902. Serial No. 117,960.

An elastic-fluid turbine, the combination with the casing or shell and the movable and stationary elements of the turbine inclosed by said casing or shell, of means for indicating the relative position of the movable and stationary elements while the turbine is running, substantially as set forth.

760,114. PNEUMATIC-VALVE FOR ORGANS. William E. Haskell, Brattleboro, Vt., assignor to Estey Organ Company, Brattleboro, Vt., a Corporation of Vermont. Filed Aug. 21, 1903. Serial No. 170,304.

760,115. PNEUMATIC-COUPLER FOR PIPE OR REED ORGANS. William E. Haskell, Brattleboro, Vt., assigner to Estey Organ Company, Brattleboro, Vt., a Corporation of Vermont. Filed Aug. 21, 1903. Serial No. 170,305.

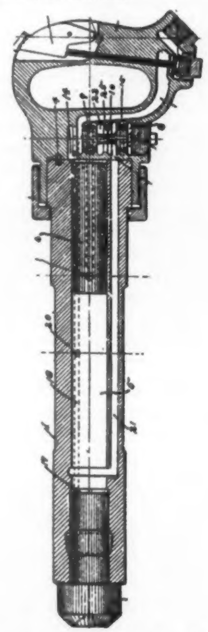
760,190. COMPRESSED-AIR LUBRICATOR. George W. Gapen, Milwaukee, Wis. Filed Dec. 6, 1902. Serial No. 134,114.



760,187. AUTOMATIC PNEUMATIC SIGNAL SYSTEM. Henry T. Farnsworth, Glade Spring, Va. Filed July 29, 1903. Serial No. 167,507.

A signal system, the combination of the casing having two ports therein, the piston mounted in said casing and carrying a piston-rod, an adjustable cap mounted on said piston-rod and designed to bear on the under side of a rail adapted to be operated by the depression of said rail, a spring-pressed slide-valve carried by said piston and located to establish communication between said ports, said casing being provided with an air connection, substantially as described.

760,195. FLUID-PRESSURE IMPACT-TOOL. Carl R. Green, Pittsburg, Pa. Filed Dec. 2, 1903. Serial No. 183,436.



A fluid-pressure power-hammer having a cylinder and a reciprocating hammer therein, a valve which governs the flow of motive fluid into and its exhaust from said cylinder, an exhaust-port communicating with the cylinder some distance from its forward end whereby the fluid will be compressed at this end of the piston, and a port leading from said end to the valve so that the said compressed fluid will shift the latter, said port communicating with the cylinder at a second point which permits live fluid to enter at the end of the forward stroke of the hammer for supplementing the pressure of the compressed air to facilitate the shifting of the valve.

760,244. SHELL-FILLING MACHINE. Harry M. Pierce, Wilmington, Del. Filed May 9, 1903. Serial No. 156,472.

760,277. AIR-CURRENT MOTOR FOR CLOCKS OR LIGHT MACHINERY. Julius O. F. Thoss, St. Louis, Mo. Filed Oct. 31, 1903. Serial No. 179,271.

The improved motor for actuating self-winding clocks, etc., comprising a propeller adapted to be driven by a current of air ascending in a chimney or stack, a speed-reducing train of gearing connected to said propeller, a brake-wheel 17 connected to said propeller, the drive-wheel of a clock, an endless chain mounted upon said drive-wheel and connecting the same to the said train of gearing, a power-storing device such as a weight, a roller connecting said power-storing device to such endless chain, a cam-plate 45 mounted to rock in a plane below said power-storing device, an arm 52 projecting from said cam-plate, a chain 53 connecting said arm to said power-storing device, a vertical brake-lever 41 pivoted intermediate of its ends and having a roller 43 at its lower end adapted to be engaged by said cam-plate to oscillate said lever, a brake-shoe 34 adapted for forcible contact with said brake-wheel, and suitable connections between the upper end of said brake-lever and the said brake-shoe, whereby said brake-shoe will be forced into contact with or released from said brake-wheel when said cam-plate is rocked, substantially as specified.

760,282. FLUID-PRESSURE BRAKE. Walter V. Turner, Wilkinsburg, and Edward A. Wright, Edgewood Park, Pa., assignors to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Sept. 26, 1903. Serial No. 174,732.

760,437. RAILWAY-BRAKE. Andrew J. Dunmire, Irwin, and Harvey Bair, Turtlecreek, Pa. Filed Apr. 22, 1903. Serial No. 153,790.

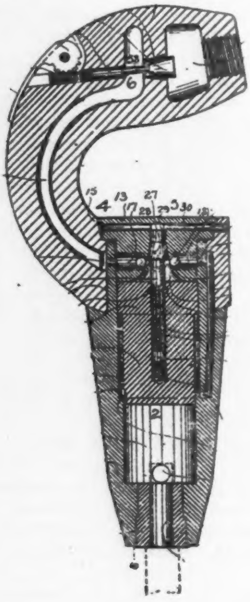
760,449. VALVE. George G. Guy, Batavia, Ill., assignor to United States Wind Engine & Pump Company, Batavia, Ill., a Corporation of Illinois. Filed Feb. 24, 1903. Serial No. 144,640.

760,465. FLUID-PRESSURE BRAKE. Harry R. Mason, Chicago, Ill., assignor to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Sept. 12, 1902. Serial No. 123,145.

760,471. PNEUMATIC-DESPATCH-TUBE CARRIER. Charles A. Murphy, Chicago, Ill. Filed Feb. 18, 1904. Serial No. 194,168.

760,329. PNEUMATIC TOOL. Richard W. Funk, New York, N. Y., assignor to Hudson Machine and Pneumatic Tool Co., Jersey City, N. J., a Corporation of New Jersey. Filed June 12, 1902. Renewed Apr. 6, 1904. Serial No. 201,913.

An improved device of the class described, a barrel member, a hammer member slidable therein, an air-inlet in the barrel member, an inlet-valve for the air-inlet, an air-outlet in the barrel member, and an outlet-valve for the air-outlet actuated by the hammer member and controlling said inlet-valve.



An improved device of the class described, a barrel member, a hammer member slidable therein, pressure-inlet means in the barrel member, and pressure-outlet means in the barrel member; said pressure-inlet means embodying a ball-valve, a valve-casing for said ball-valve arranged radially of the barrel member and provided at its inner end with a seat, and means for supplying pressure to said valve-casing; and said pressure-outlet means embodying an exhaust-port, and a conical valve for said exhaust-port connected with said hammer member and arranged to maintain said ball-valve in unseated position when said conical valve is in seated position.

760,488. VALVE. Harry C. Root, Charleston, Ill. Filed Mar. 19, 1904. Serial No. 198,898.

A pressure-reducing valve, consisting of a pair of initial-pressure cylinders, each having an induction-port, a piston structure consisting of a pair of separated heads, one arranged in each of said initial-pressure cylinders, a secondary-pressure chamber arranged adjacent and communicating with one of said piston-heads in opposition to its initial-pressure cylinder and having a by-pass leading around said piston and communicating with the opposed initial-pressure cylinder, said pistons being arranged to control the effective area of the by-pass, and a secondary-pressure-determining device arranged to engage the piston structure in opposition to the pressure exerted thereon from the secondary-pressure chamber.

760,575. MINING-MACHINE. Frank L. Sessions and George B. Norris, Columbus, Ohio, assignors to Joseph A. Jeffrey, Columbus, Ohio. Filed Jan. 6, 1903. Serial No. 138,044.

A mining-machine, the combination with the bed, the carriage moving forward and back thereon, and the cutter-chain on the carriage, of a lubricant-receptacle on the carriage arranged to deliver oil to the chain, the valve controlling the flow of oil from said receptacle, means for holding the valve normally closed, the tripping devices secured at intervals along the bed and means interposed between said tripping devices and the valve adapted to engage with said tripping devices to operate the valve, substantially as set forth.

760,595. CUT-OFF APPARATUS FOR GAS OR LIQUID SUPPLY PIPES. Frederick W. A. Wiesebrock, New York, N. Y. Filed Aug. 27, 1903. Serial No. 170,901.

760,659. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Oct. 5, 1903. Serial No. 175,833.

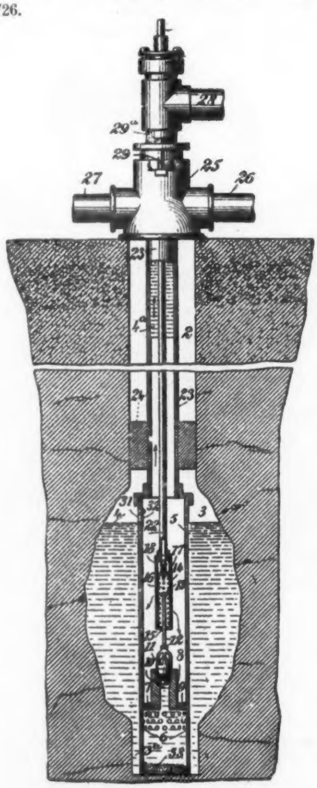
760,701. PNEUMATIC CARRIER. Otto S. Pike, Malden, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Nov. 3, 1902. Serial No. 129,807.

760,775. SAND-BLAST MACHINE. Frank P. Boland, Providence, R. I. Filed Feb. 26, 1904. Serial No. 195,364.

A sand-blast machine provided with a main operating-chamber, the combination of a sand carrying or circulating pipe communicating with the lower end of said chamber, an air-blast pipe connected with said pipe, a stationary hollow top fitting having an open discharge-nozzle extend-

ing downwardly into said chamber in communication with the outlet ends of said circulating and air pipes, an inner discharge-pipe secured to or forming a continuation of said pipe extending downwardly through fitting and into the nozzle, and an exhaust-pipe in open communication both with the chamber and with the circulating-pipe, whereby the pressure upon the flowing sand in the latter pipe is relieved before it escapes from the discharge-pipe, substantially as described.

760,903. MECHANISM FOR RAISING LIQUIDS FROM DEEP WELLS. Thomas F. Moran, De Young and Fred J. Moser, Kane, Pa. Filed July 16, 1903. Serial No. 165,726.

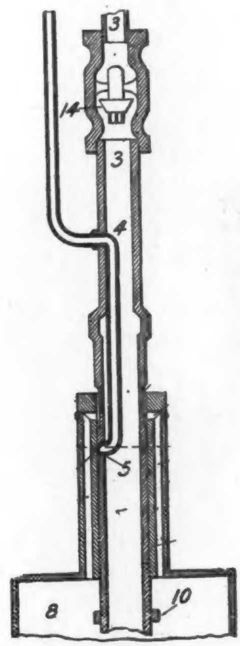


An apparatus of the character described, the combination of a casing provided with tubing for carrying liquids to the surface of the earth, an air-pipe disposed within said tubing, an air-nozzle connected with said air pipe, and a valve controlling communication between said air-pipe and said air-nozzle.

An apparatus of the character described, the combination of a casing, tubing connected therewith for the purpose of conveying liquid therefrom to the surface of the earth, valve mechanism connected with said casing for admitting a liquid to the same, said valve mechanism being disposed at a predetermined level for the purpose of preventing the upper level of the liquid in the well outside of the casing from being lowered below said predetermined level, and a tubular member mounted within said casing and free to reach to a point adjacent to the lower end thereof without interfering with the action of said valve mechanism.

761,024. COUPLING FOR AIR-BRAKE HOSE. Archibald F. Allan and John A. Lenhoff, Wilmington, Del. Filed Nov. 13, 1903. Serial No. 181,013.

761,065. PNEUMATIC PUMP. Ralph W. Elliott, San Francisco, Cal. Filed Mar. 14, 1904. Serial No. 197,978.



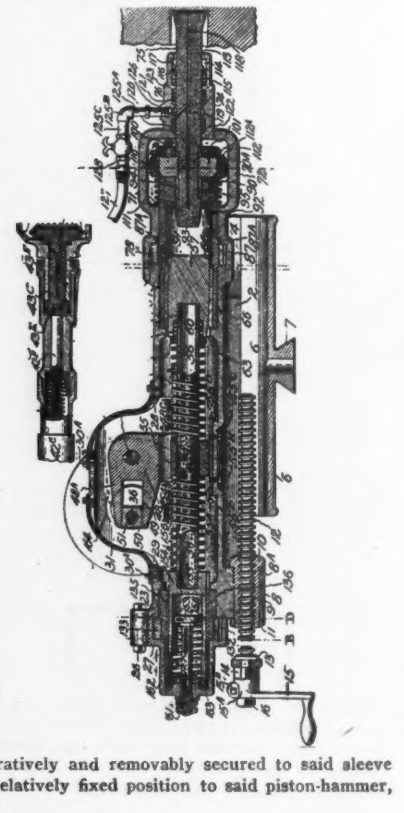
A pneumatic pump, the combination of a compressed-air pipe, a water-discharge pipe, a cylinder having a neck sliding on said water-discharge pipe, said water-discharge pipe and neck thus forming valve-operating mechanism for control-

ling admission of the compressed air from said pipe to the cylinder, the water-discharge pipe leading to a point near the bottom of the cylinder, and having a check-valve therein and the cylinder having an inlet-valve for the water, substantially as described.

761,092. VACUUM-MACHINE FOR CANS, &c. Charles B. McDonald, Chicago, Ill. Filed Apr. 7, 1902. Serial No. 101,837.

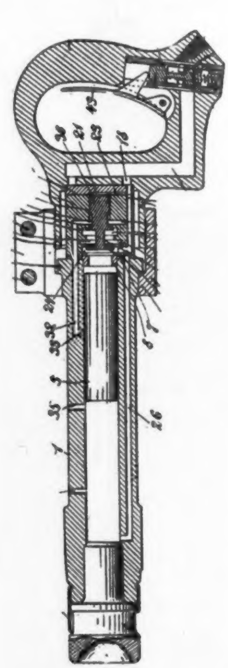
761,153. ROCK-DRILLING ENGINE. Lafayette Durkee, Denver, Colo. Filed Apr. 27, 1903. Serial No. 154,487.

A rock-drilling engine, the combination with the casing and its screw-feed-sliding supporting-base, of a piston-hammer reciprocally mounted in said casing, a hammer having a spirally-grooved peripheral surface at one end, a spirally-fluted nut rotatably mounted on said hammer, a sleeve secured to said nut, a rock-cutting drill-bit



operatively and removably secured to said sleeve in relatively fixed position to said piston-hammer, means including coiled springs operatively mounted on said piston-hammer for reciprocating said piston-hammer against said drill-bit, a straight-fluted portion on the rear end of said piston, a straight-fluted nut rotatably mounted in said casing having its fluted portion in operative mesh with the straight flutes on said piston-hammer, a ratchet-toothed ring on said nut, and spring-controlled pawls arranged in operative relation to said ratchet-teeth and provided with a resilient buffer-support, substantially as described.

761,414. IMPACT-TOOL. William Secher and Louis W. Greve, Cleveland, Ohio. Filed Nov. 30, 1903. Serial No. 183,089.



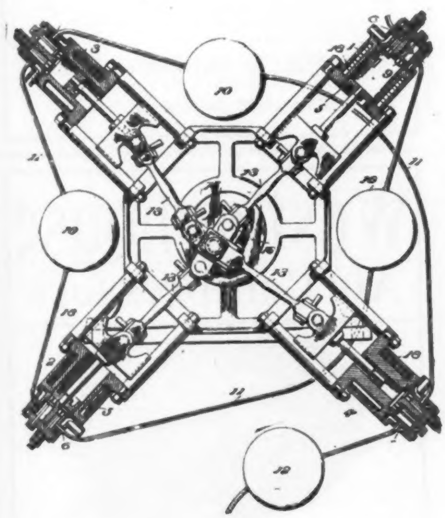
An impact-tool of the type described, a valve to control the admission and exhaust to and from the cylinder, said valve being constructed and arranged with a permanent live-air admission against one face to force it in one direction and with an opposed face exposed to air compressed between it and the plunger to force it in the opposite direction.

An impact-tool, the combination of a cylinder, a plunger reciprocable therein, a valve-chamber,

and a differential piston-valve in said chamber controlling the inlet and exhaust of motive fluid to and from the opposite ends of the cylinder, said valve having a pressure-face exposed to air compressed by the plunger at one end of its stroke to be moved in one direction and having another pressure-face permanently exposed to motive-fluid pressure to be moved in the opposite direction.

761,208. RAILWAY-SIGNAL. John P. Coleman, Edgewood, Pa., assignor to the Union Switch & Signal Company, Swissvale, Pa., a Corporation of Pennsylvania. Filed Sept. 4, 1903. Serial No. 171,940.

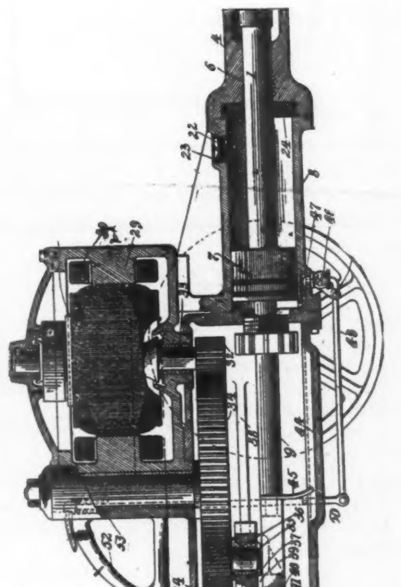
761,598. AIR-COMPRESSOR. Harry M. McCall, Pittsburg, Pa., assignor to Pittsburg Gas Engine Company, Pittsburg, Pa. Filed Mar. 7, 1902. Serial No. 97,080.



A stage air-compressor consisting of a series of pairs of pumps radially arranged with relation to a common center and fitted with pistons of different areas, the low-pressure pump of each pair being in the same axial line as the high-pressure pump of the pair, a revolving crank connected with all said pistons and adapted to operate them successively, air connections between the low-pressure pumps and pumps of next higher pressure and adapted to lead the air from a lower-pressure pump to the next higher-pressure pump while the pistons thereof are moving in different directions and from the lowest-pressure pump successively through the intermediate pumps to the highest-pressure pump.

761,602. FLUID-PRESSURE TOOL. Alexander Palmros and Carson W. Damron, Fairmont, W. Va. Filed Sept. 6, 1902. Renewed Sept. 28, 1903. Serial No. 174,875.

In combination with a fluid-pressure-driven tool, having means for developing fluid-pressure by its instroke, a pump maintaining a supply of fluid-pressure medium to the working cylinder of the tool.



A cylinder, a piston therein, a drill-carrying element connected to the piston, means for advancing said piston by compressed air, a mechanism for retracting said piston to compress air for advancing the piston, and auxiliary means for supplying compressed air to the cylinder.

A tool in which the tool-bar is projected by fluid-pressure and retracted by a motor, the combination of a part reciprocated by the motor, having horns, a retracting-bar connected with the piston which operates the tool member, a pair of dogs pivoted on the retracting-bar adapted to engage the horns on the reciprocating part, a pin mounted in a bar in the reciprocating bar, pressing said dogs in engagement with the horns, a passage communicating fluid-pressure from the working cylinder of the tool to the said pin, and a releasing-stop at the rear limit of movement of the dogs, engaging the latter and displacing them from the horns as the retracting-bar reaches its rear limit.

761,238. ELASTIC-FLUID TURBINE. Tore G. E. Lindmark, Stockholm, Sweden. Filed June 27, 1902. Serial No. 113,529.

In combination with an elastic-fluid turbine-wheel of the outward-flow type and a casing therefor, a duct adapted to convey hot gases located within said casing and surrounding and receiving the direct impact of the escaping fluid jets from said wheel.

761,360. ELECTRO-PNEUMATIC BRAKE. John W. Cloud, London, England, assignor to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Sept. 30, 1901. Serial No. 77,101.

761,446. INFLATING-PUMP FOR PNEUMATIC TIRES. Nicholas F. Canepa, St. Louis, Mo. Filed May 28, 1903. Serial No. 159,081.

761,491. PNEUMATIC-TIRE COVER. Theodore Houben, Verviers, Belgium. Filed Dec. 15, 1903. Serial No. 185,310.

761,618. VEHICLE AIR-BRAKE. William W. Walter, Aurora, Ill., assignor of one-third to Jay D. Miller, Geneva, Ill. Filed Jan. 23, 1903. Serial No. 140,241.

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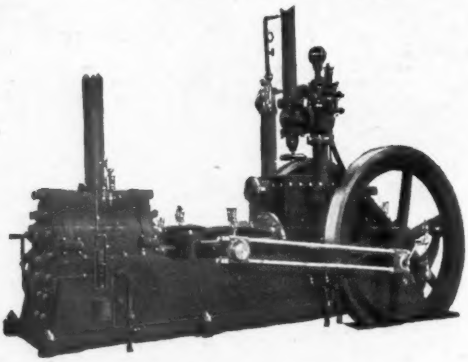

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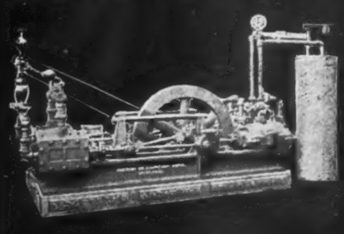

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